Engineering Library

MAY 16 1943

Heating Piping & Air Conditioning

DESIGN
INSTALLATION
OPERATION
MAINTENANCE

MAY ★ 1943

INDUSTRIAL
COMMERCIAL
AND LARGE
BUILDINGS

e 257: Journal Section of the American Society of Heating and Ventilating Engineers

The government urges all users to buy coal early! Above is a view of coal storage at an Army camp

CONTENTS . . PAGE 67

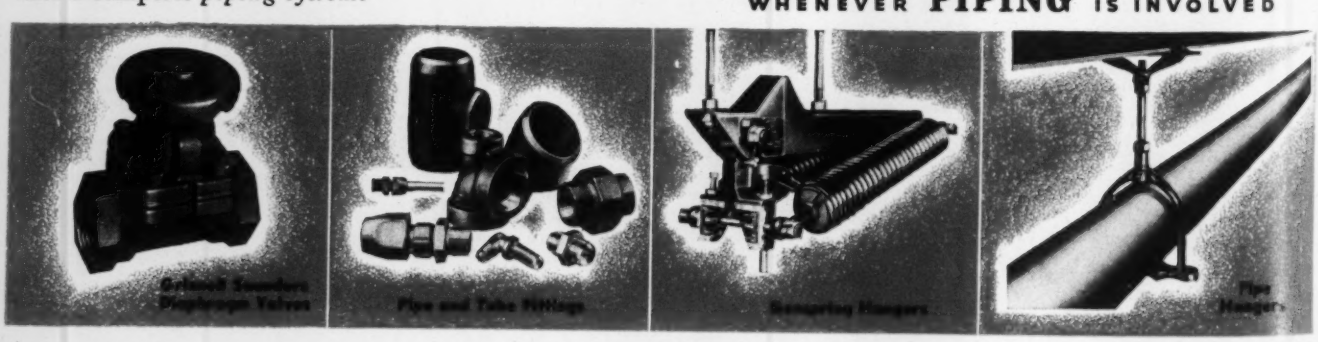
REMOVE THE PIPING FROM A PETROLEUM REFINERY and what have you left? From well to tank car an unfathomable maze of piping provides FLUID TRANSPORT.

Here, as in scores of other industries, the piping formula is made up of such components as: materials to be carried, heat, cold, expansion, contraction, pressure and corrosion. Grinnell provides the specialized engineering combined with the manufacture and fabrication of the many connecting links needed to convert a pile of pipe into a complete *piping system.*

For war construction, or maintenance and repair of existing piping, call Grinnell Company, Inc. Executive offices, Providence, R. I. Plants and offices throughout United States and Canada.

GRINNELL

WHENEVER PIPING IS INVOLVED



The Editor's Pages

LIMITATION ORDER L-38 IS AMENDED

Restrictions on deliveries of refrigerating and air conditioning machinery and equipment (including industrial type extended surface heating equipment, and industrial type humidifying equipment) were modified by general limitation order L-38 as amended April 14 by the War Production Board. The original order permitted a manufacturer or dealer to deliver on any purchase order for a system of refrigerating and air conditioning machinery and equipment or parts of such system which the War Production Board authorized on forms PD-830 or PD-831. The amended order extends permission to deliver such systems or parts on purchase orders which were placed with and accepted by a dealer, producer, or other person prior to April 6, 1943, providing such orders bear preference ratings of A-1-c or higher.

According to the terms of the order no dealer or producer shall deliver any new or used parts to the owner, lessee, or user of any used system, and no person shall accept delivery of any such parts, unless such parts are delivered either for use in "emergency repair service" and to fill a purchase order bearing a preference rating of AA-4 or higher, or to fill an "authorized order," or for direct use by the Army, Navy, Maritime Commission, or War Shipping Administration, including orders for any Army or Marine Corps post exchange or any Navy ships service department; and the parts replaced shall be disposed of in accordance with the order, if made of metal.

The order also provides that no dealer or producer shall deliver any new or used parts to the owner, lessee, or user of a "comfort cooling system" for the repair of such system, except pursuant to an "authorized order," or pursuant to a purchase order bearing a preference rating of AA-4 or higher where all the parts necessary for the "emergency repair service" for such system do not have an aggregate sales value in excess of the following: (a) $25 where the aggregate installed capacity is not over 20 hp or tons of refrigeration (ASRE specifications), (b) $50 where such capacity is over 20 hp or tons but not over 100 hp or tons, or (c) $100 where such capacity is over 100 hp or tons.

No such order for parts (having a value in excess of the applicable amount specified above) will be authorized unless it is demonstrated to the satisfaction of the War Production Board that the continued operation of such "comfort cooling system" is essential to avoid air conditions which would be intolerable or dangerous to health, and that such conditions cannot be avoided by the use of that portion of the system designed for the circulation of air, electric fans, or other power driven equipment possessed by the owner, lessee, or user of the system and/or by opening of windows or doors, the order states.

An exemption in the order covers the temporary delivery of a used system or parts to a dealer or producer for repair and redelivery to the same owner, the redelivery of a repaired system or part to the same owner, or the loan of a new or used system or parts for a period not to exceed 30 days pending the performance of "emergency repair service" to a used system or parts. The delivery of a used system or parts for junking or scrapping is also exempted.

The order includes six lists. List A shows items which may be delivered unrestricted, and includes evaporative coolers of 2000 cfm or less. List B shows items which may be delivered only as indicated therein. List C is a listing of essential uses of refrigeration and air conditioning. In list D are given items which may not be produced for any purpose, including evaporative coolers of 2000 cfm or less, and self-contained unit air conditioners of 2 hp or less. List E comprises items which may be produced only for specific purchasers or purposes.

List F defines a "comfort cooling system" as any system, of any size, operated or installed for the purpose of lowering the temperature and/or humidity of air in any building, room or other enclosure used as, or located in any of the following: Amusement parks; animal hospitals; auditoriums, ballrooms, dancing studios, and dance halls; banks and loan associations; bars, cocktail lounges, and beer parlors; bowling alleys; concert halls; funeral parlors; golf clubs, country clubs, and athletic clubs; hotels and apartment houses; moving picture houses; night clubs; office buildings and offices, public or private; railway, streetcar and bus stations and terminals; residential buildings and dwellings of all kinds; restaurants, cafeterias, and other places selling meals, food or beverages; schools; service establishments, such as laundries, cleaners and dyers, tailor shops, barber shops, "beauty" parlors, automobile sales and service shops, and repair shops of all kinds; skating rinks; stores, selling any kind of products, material or merchandise, at retail or wholesale (excluding manufacturing establishments); and theaters.

The term "comfort cooling system" shall not include, says the order, any such system used to air condition a building, room or other enclosure used chiefly for purposes not listed above; or any system designed, necessary and used, in substantial part for the refrigeration and storage or processing of food, ice (except in skating rinks), or other materials or products requiring refrigeration, temperature control, or freedom from dust or other impurities; or such part of a system as may be necessary and used for the circulation of air, or necessary and used for raising the temperature of air during cold weather to a degree which is comfortable or tolerable for persons (comfort heating).

CMP REGULATION REPLACES OLD P-100

Preference rating order P-100, the general repair, maintenance, and operating supplies order, was revoked by the War Production Board last month. The action was taken in view of the fact that producers who formerly used the ratings assigned under P-100 are permitted to operate within the terms of CMP regulation No. 5. The effective date of the revocation was April 2, 1943.

CMP regulation No. 5 assigns a preference rating of AA-1 to producers covered in its schedule I, AA-2X to those covered in schedule II, and an A-10 rating to business activities not mentioned in either schedule.

The revocation order provides that any serial numbered copy of P-100 issued to a producer in Canada shall remain in effect until it is specifically revoked or until the Canadian producer becomes eligible to apply ratings assigned by CMP regulation 5.

FHA LOANS FOR FUEL CONSERVATION

The Federal Housing Administration has established a delayed payment plan for loans insured under its title I program which finance fuel conservation installations this spring and summer, Federal Housing Commissioner Abner H. Ferguson announced last month.

The FHA has notified private lending institutions that initial payments on loans made between April 20 and September 1 may be deferred until November 1, 1943, if the entire proceeds are used for the conversion of heating equipment to the use of other fuels, for application of insulation within existing structures, or for installation of storm doors, storm windows, or weatherstripping.

The Editor's Pages

POST WAR BOOM IN INDUSTRIAL AIR CONDITIONING FORESEEN

A post war boom in industrial air conditioning was predicted by John E. Haines, manager of the air conditioning controls division of the Minneapolis-Honeywell Regulator Co., at a conference of the company's eastern representatives last month.

"A survey of industrial engineers indicates that control of temperature and humidity in plants building airplane and tank engines has resulted in an impressive increase in production involving high precision," he said, "and all indications are that post war construction will take into account this new trend."

C. O. Fanning, of the F. W. Dodge Corp., told the conference that a tremendous backlog of building plans is accumulating for the post war period.

STOKER MAKERS PLAN FOR FUTURE

Organization of a post war planning committee for the stoker manufacturing industry was announced last month by J. M. McClintock, president of the Stoker Manufacturers' Association, following an annual meeting of the association's executive committee. Membership will consist of the chairmen of each of the association's standing committees. In this way, every phase of the industry's problems as related to both the war effort and post war plans will be taken into consideration.

Mr. McClintock also has announced the approval by the executive committee of the organization of a new anthracite stoker manufacturers' section.

AIR CONDITIONING FIRM ADDS HEATING, PIPING

At a meeting of the stockholders of Buensod-Stacey Air Conditioning, Inc., held last month, it was voted to change the corporate name to Buensod-Stacey, Inc.

When the corporation was organized, it was for the purpose of acting as a personal service organization practicing the art of air conditioning. One of the primary functions of air conditioning is heating, which is vitally necessary and always a major part of the design and equipment. Initially, heating installations using radiation as basic elements were not generally engaged in by this organization. Experience, however, in the coordination of direct radiation with the necessary control of temperature in air conditioning led to the conclusion that a complete installation should be made by one contractor and thereby one responsiblity for effecting the results to be obtained by air conditioning.

For the past two years, due to war restrictions on air conditioning, the corporation has done a considerable amount of heating, power plant, and process piping. Success in this line has led to a decision that the organization is permanently in the heating business, as well as air conditioning and ventilation.

NEW CLASS B PRODUCT SYMBOLS ASSIGNED

An entirely new set of Class B product symbols has been assigned to items falling within the jurisdiction of the various industry divisions of the War Production Board, it was announced April 14. These new symbols replace the former S-3 designation used for B products during the second quarter. The new symbols will not be applicable until the third and subsequent quarters.

RADIANT HEATING DISPLAY

War broke a precedent in Pittsburgh recently when Kaufmann's, one of the city's leading department stores, dedicated a portion of its consumer goods display space to the industrial wares of heavy industry. The occasion was a war production display entitled "Pittsburgh Industry at War" designed to better acquaint the public with the war effort of principal local concerns. Shown below is the display which A. M. Byers Co. contributed to the showing. The display places primary emphasis on the use of Byers' wrought iron in other war plants. Principal attraction was a model plant which swings back on hinges to reveal a floor lined with glowing lucite tubes, illustrating radiant heating as installed in numerous war plants and military bases

The purpose of applying the new symbols to B products is to provide the War Production Board with a means of determining at mill levels the uses to which controlled materials will be put.

Official B product program identification symbols include:

General industrial equipment: G-6 motors and generators, including motor generator sets, except generators for internal combustion engines, motors made by electric appliance manufacturers for incorporation therein, and motors for elevators and mine locomotives; G-7 compressors and dry vacuum pumps, reciprocating; G-7 pumps, industrial; G-8 mechanical power transmission equipment, industrial; G-9 heat exchangers; J-1 welding equipment and apparatus, electric; J-1 welding equipment and apparatus, non-electric; J-2 welding rods and electrodes; J-3 electric motor controls and control equipment; J-4 refrigeration and air conditioning equipment (except domestic refrigerators); J-5 fans, blowers and exhausters (except turbo blowers, soot blowers and domestic propeller type fans) of a portable nature; and J-5 dust collecting equipment, industrial.

Health, safety and technical supplies division: J-6 blowers and vacuum pumps (laboratory).

Plumbing and heating division: J-8 boilers, low pressure, cast iron; boilers, low pressure, steel; coils, blast heating; convectors, heating; radiators, cast iron; unit heaters and unit ventilators; warm air distribution equipment, registers, stove and smoke pipe; warm air furnaces; burners, gas industrial; burners, oil; burners, combination oil and gas (industrial); gas conversion burners, domestic; oil burners, domestic; stokers, domestic; heating system controls; and hot water equipment, domestic (except electric).

Shipbuilding division: K-1 valves, steel; K-2 valves, except steel; K-3 pipe fittings, steel; and K-3 pipe fittings, except steel.

COPPER SCRAP HEADS MATERIAL SHORTAGE LIST

This is the goal the War Production Board hopes industry will achieve in 1943, says the Business Press Industrial Scrap Committee:

A 62½ per cent increase in the flow of copper, brass and bronze scrap. This will result in capacity operations of the nation's scrap copper refineries. The 1,625,000 tons collected will produce approximately 1,000,000 tons of copper to be used in the war effort.

Heating Piping & Air Conditioning

with which is merged the Aerologist

Design, Installation, Operation, and Maintenance

Industrial, Commercial, and Large Buildings

Board of Consulting & Contributing Editors

N. R. Bernz, Sabin Crocker, R. C. Doremus, Philip Drinker, E. L. Ellingwood, Walter L. Fleisher, F. E. Giesecke, William Goodman, William A. Hanley, J. J. Harman, R. S. Hawley, E. P. Heckel, R. E. Hieronymus, J. C. Hornung, John Howatt, Lee P. Hynes, C. W. Kimball, Dwight D. Kimball, A. C. Kirkwood, Charles S. Leopold, Samuel R. Lewis, H. C. Murphy, Alfred J. Offner, F. B. Rowley, Robert P. Schoenijahn, Kalman Steiner, T. S. Tenney, Rush D. Touton, Eph. A. Tyler, W. H. Wilson

Editor
C. M. Burnam, Jr.

Assistant Editor
Margaret Marshall

Advertising Staff

Wallace J. Osborn
New York
Telephone: Murray Hill 9-8293

James D. Thomas
Chicago
Telephone: State 6916

Robert A. Jack
Cleveland
Telephone: Yellowstone 1540

J. Howard Tinkham
Los Angeles
Telephone: Richmond 6191

Publisher
Frank P. Keeney

Manager
Chas. E. Price

Published monthly by the Keeney Publishing Co., 6 N. Michigan Ave., Chicago. Telephone: State 6916/ Subscriptions: U. S. and possessions, Canada, Mexico, Central America, South America, $2.00 per year; other, $4.00. Current copies, U. S. and possessions, 25c each, back copies 50c each. January, 1943, issue, $1.00 per copy/ Member of Audit Bureau of Circulations and the Associated Business Papers, Inc./

Copyright, 1943, by the Keeney Publishing Co.

IN THIS ISSUE

Volume 15 **May, 1943** **Number 5**

The Editor's Pages (news and comment).....front section 63

Piping Services at the New Bell Telephone Laboratory, by Franklin P. Hunt..... 217

Refrigeration Groups Discuss War Problems..... 219

How to Meet Wartime Heating and Piping Problems..... 220

Conversion from Oil to Coal Fired Steam Generation, by Samuel I. Rottmayer..... 220

Breaking Bottlenecks in Piping Materials, by G. W. Hauck.. 224

The Fuel and Heating Program at Army Cantonments, by Louis C. McCabe..... 228

Fuel Oil Rationing—How Did It Work Out Last Year?..... 231

Plan Worked Reasonably Well, Improvement Possible, by E. M. Mittendorff..... 231

These Changes Would Benefit Public and Industry, by C. H. Randolph 232

Recent Amendments to Fuel Oil Rationing Order..... 233

OPA Announces Features of Fuel Oil Rationing Program for Next Year 234

Sam Lewis' Page (a new feature)..... 235

Testing Toxic Atmospheres, by N. R. Bernz..... 236

WPB Releases Small Fans..... 237

Air Recovery by Gas Adsorption Cuts Equipment Weight and Costs 238

Heating the Ships for Victory, by John Clarke..... 240

Electric Air Cleaning Controls Oil Mist from Machine Tools, by E. H. R. Pegg..... 242

Ventilation of New Cornell Chemistry Building..... 242

Water Sprayed Direct Expansion Coils—Their Theory and Characteristics, by William Goodman..... 243

Heat Transfer Coefficients for Roof Constructions, by Paul D. Close (answer to a reader's question)..... 248

Blast Furnace Air Conditioning..... 249

"Bone Dry" or "Three Grains"?, by Ralph H. Sweetser.... 249

One Grain or Lower, by Gerald F. Mannion and Norman Weinstein 251

Why Three Grains?, by L. L. Lewis..... 253

A History of Piping, by M. A. Hasselmann..... 254

Equipment Developments.....back section 137

Trade Literature.....back section 145

Useful Information.....back section 153

Coming Events.....back section 162

Index to Advertisers.....back section 166

Journal Section of the American Society of Heating and Ventilating Engineers

Semi-Annual Meeting at Pittsburgh..... 257

Spray Nozzle Performance in a Cooling Tower, by L. M. K. Boelter and S. Hori..... 259

Fuel Oil Rationing Questionnaire, by John Howatt..... 267

Members on Active Duty..... 269

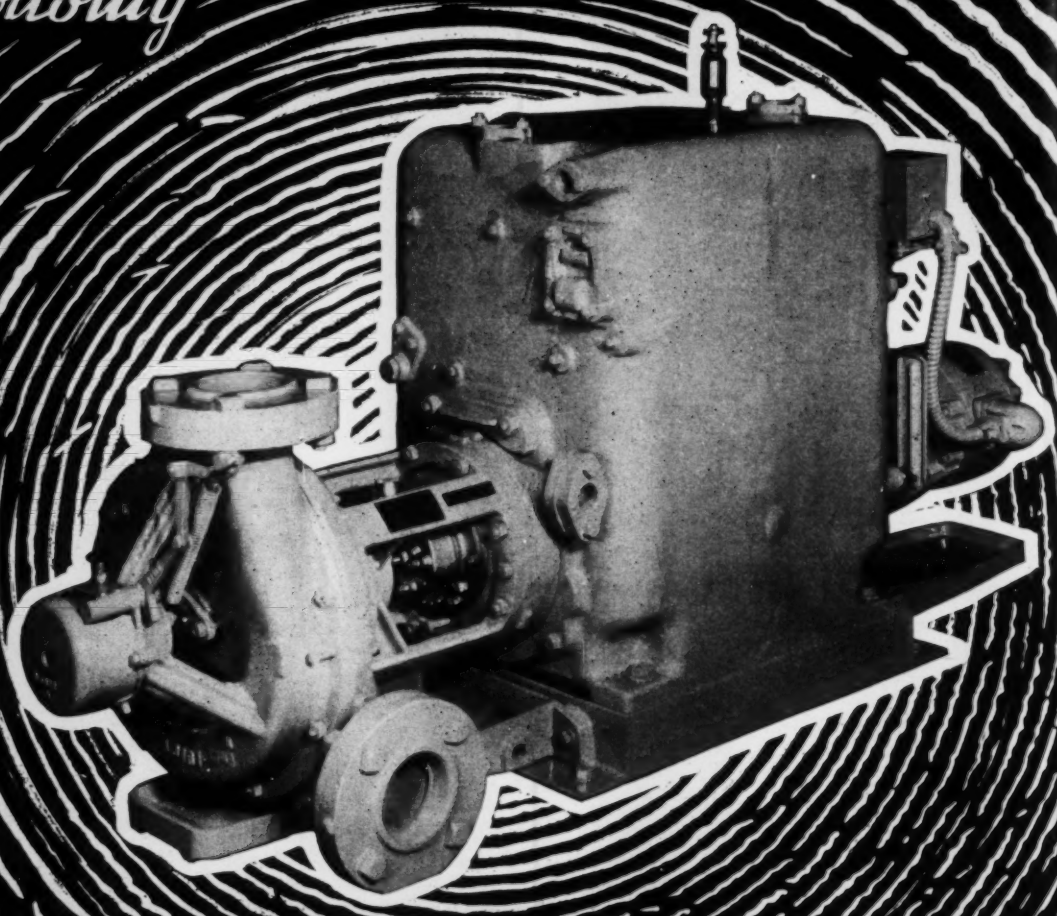
Summary of Local Chapter Meetings..... 271

Candidates for Membership..... 274

Candidates Elected..... 275

Officers, Council, and Committees.....276

Centralized Heating Economy



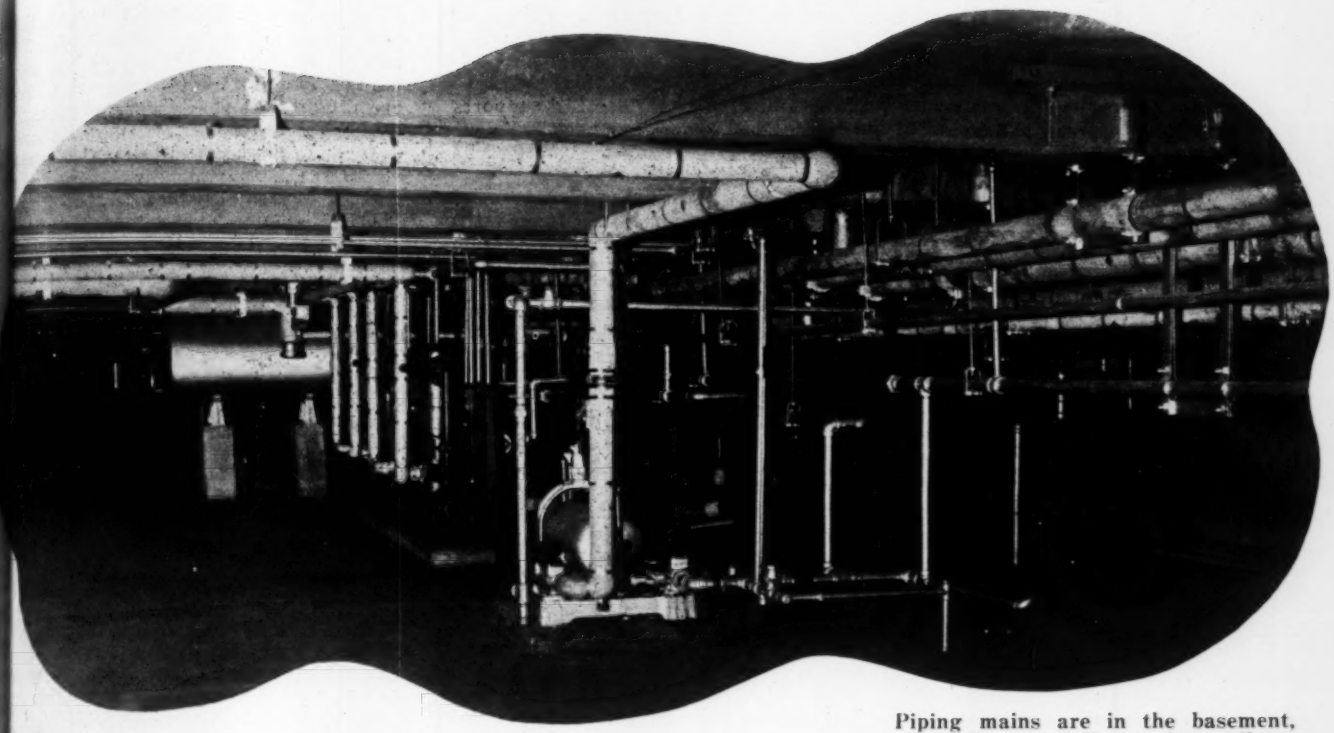
A RETURN LINE VACUUM PUMP THAT CUTS HEATING COST.

This unusual pump needs no electric current, cutting out greatest item of pump operating expense.

More important, this pump insures absolutely uniform circulation in system. That means continuous steam economy.

Simple, compact, one moving element, no wearing parts, no internal lubrication. Bulletin No. 203 gives the facts. Your copy is waiting.

THE NASH ENGINEERING COMPANY
SOUTH NORWALK, CONNECTICUT, U. S. A.



Piping mains are in the basement, which is essentially a pipe gallery. The ceiling is low to permit working on the piping without use of ladders

PIPING SERVICES at the NEW BELL TELEPHONE LABORATORY

Research Buildings Require Many Special Facilities for Present and Future Needs . . . By Franklin P. Hunt

SUMMARY—Occupation of the new Bell Telephone laboratory described here began just prior to our entry into the war, which was particularly fortunate as it made additional facilities available which are being used almost exclusively for research and development projects associated with the war. . . . These buildings require many special services, and the piping must provide for the alterations and extensions demanded by the frequently changing space needs of experimental work. . . . How these problems were solved, and the materials used, are described by Mr. Hunt, of the Bell Telephone Laboratories

A RURAL location for part of the Bell System's research and development work has long been contemplated and after extensive preparations it has taken form. In a group of new buildings on a 200 acre site are now accommodated over 800 of the more than 6000 employees of the laboratories.

A research laboratory requires many special mechanical and electrical facilities and much thought was given in designing the buildings to make them available not only for present needs but also to provide for the alterations and extensions demanded by the frequently changing space requirements of experimental work. Fifteen of these services are regularly supplied and distributed to individual laboratories and there are also special services in addition. The regular services include steam; hot, cold, and distilled water; compressed air and vacuum, oxygen, hydrogen, and nitrogen gas, as well as illuminating gas; electrical power at two voltages; telephone; and drains. Gases, laboratory hot water, and distilled water are distributed from mains in the attic. All other mains are installed in the cellar, which was constructed primarily as a pipe gallery and is low enough to allow workmen to reach the piping for repairs without ladders.

Piping and Fittings

Water mains up to 3 in. diameter are type B copper tubing with soldered fittings, and those 4 in. and over are cement lined cast iron with bell and spigot joints and fittings. Hot water mains and risers are also type B copper tubing. Distilled water is distributed in IPS aluminum pipe with special aluminum screwed fittings. Drinking water is piped in tin lined copper tubing with tin lined copper sweat fittings. The chilled

water piping for air conditioning and for cooling the drinking water is galvanized steel with screwed fittings.

Hydrogen, nitrogen and oxygen gases are distributed in type L copper tubing with sweat fittings. Illuminating gas is carried underground in cast iron pipe with bell and spigot joints, and within the buildings in black steel with galvanized screwed fittings of malleable iron. All steam and compressed air piping is black steel and has cast iron screwed fittings. Type K copper tubing is used for vacuum.

Where a high concentration of acid waste was anticipated, 3 in. glazed stoneware pipe is installed for chemical wastes and vents; in other locations 3 in. salt glazed sewer pipe is used, and the branch drains are heavy duty lead. Electrical wiring is in steel conduit, except for runouts along laboratory walls where it is in special metal troughs.

Piping Arrangements

From the service mains in the attic and cellar, risers are installed in chases which are situated in the outside walls at 6 ft intervals. The risers for any one service occur once in 24 ft except those for the heating and chemical drains which appear in each chase. Horizontal branches extend from the risers at each floor behind the metal wainscoting and below the window sills for a distance of 24 ft. There are two plugged tees at each center line between windows; this provides for the extension of any service into the working spaces at 6 ft intervals.

To get these services from the horizontal branches at the side walls to laboratory benches, special supports were devised for quick attachment to the room partitions. Throughout the laboratories all subdividing partitions are built up of double steel sheet panels which are 4 ft wide, with few exceptions, and extend from floor to ceiling. The side members of the panel units are made of heavier steel than the faces and are slotted every 6 in. A special box shaped fitting with wings projecting from two opposite sides and key holes in the other faces is slipped into the vertical space between two panel units, turned to engage the wings in a slot in each panel, and then driven down; this holds the fitting securely in place. The key holes in the fitting are nearly flush with the panel surface and provide the points of support for pipes and other equipment mounted against the partitions.

A variety of mounting strips, pipe clamps, angle plates, and shelf brackets are available for attachment to these key hole fittings. Cover plates, either plain or with matching holes punched in them where any of the key holes have been used, are clipped into place to cover the 3 in. space between the partition panels. This arrangement permits the easy installation or removal of wiring and piping without mutilating the panels.

From the plugged tees in the branches behind the wainscoting, the laboratory services are run out through a narrow slotted hole with deep sides called a "shadow box"; this prevents exposing the piping behind the wainscoting. Where services are required at "island" benches, distant from the room walls, pipes are dropped from the branches behind the wainscoting and brought out into the room in steel troughs in the floor fill. The troughs have removable steel covers with slots where the services turn up to the benches.

These partition details and pipe supports permit great flexibility in changing laboratory space in a minimum of time. Panels and supports can be reused indefinitely with only an occasional painting.

Gas Distribution System

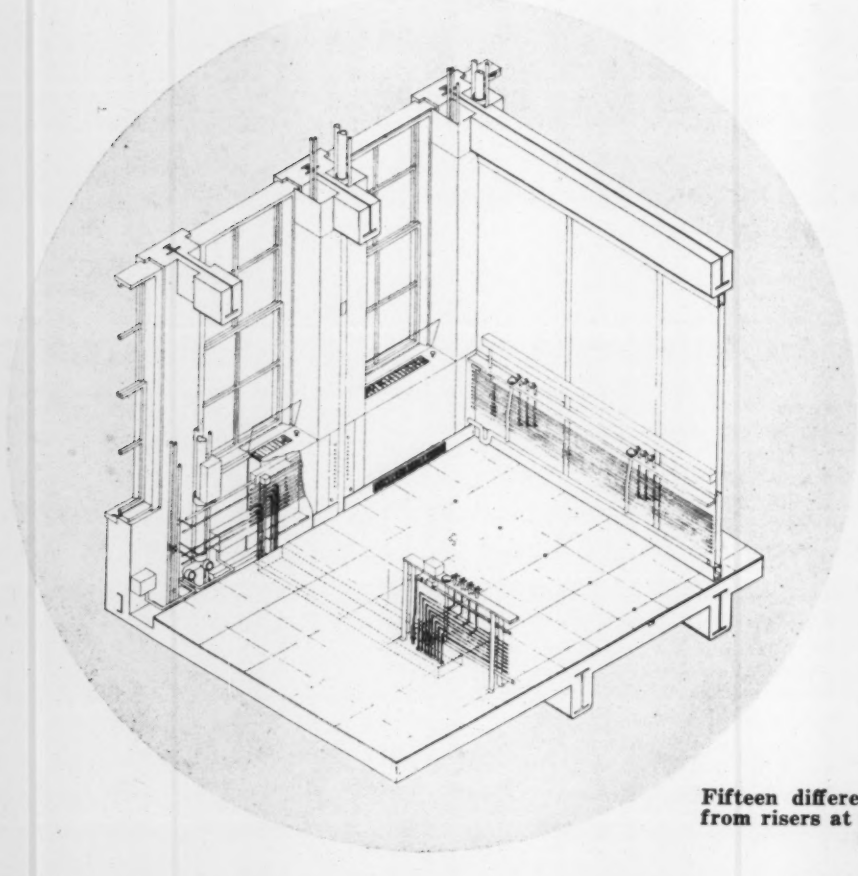
Hydrogen, oxygen, and nitrogen are distributed to individual laboratories from a central supply. To avoid fire hazard the hydrogen is stored in pressure tanks in one room and the oxygen and nitrogen in another. Pressures are reduced in two stages through manifolds from 2000 to 50 and then to 10 psi. Eight cylinders are connected to the system at a time; four are in use and four held in reserve. There is space within the distribution room for additional tanks. A rate of flow gage in the hydrogen lines keeps the amount used in any room below that which could form an explosive mixture.

Ventilating System

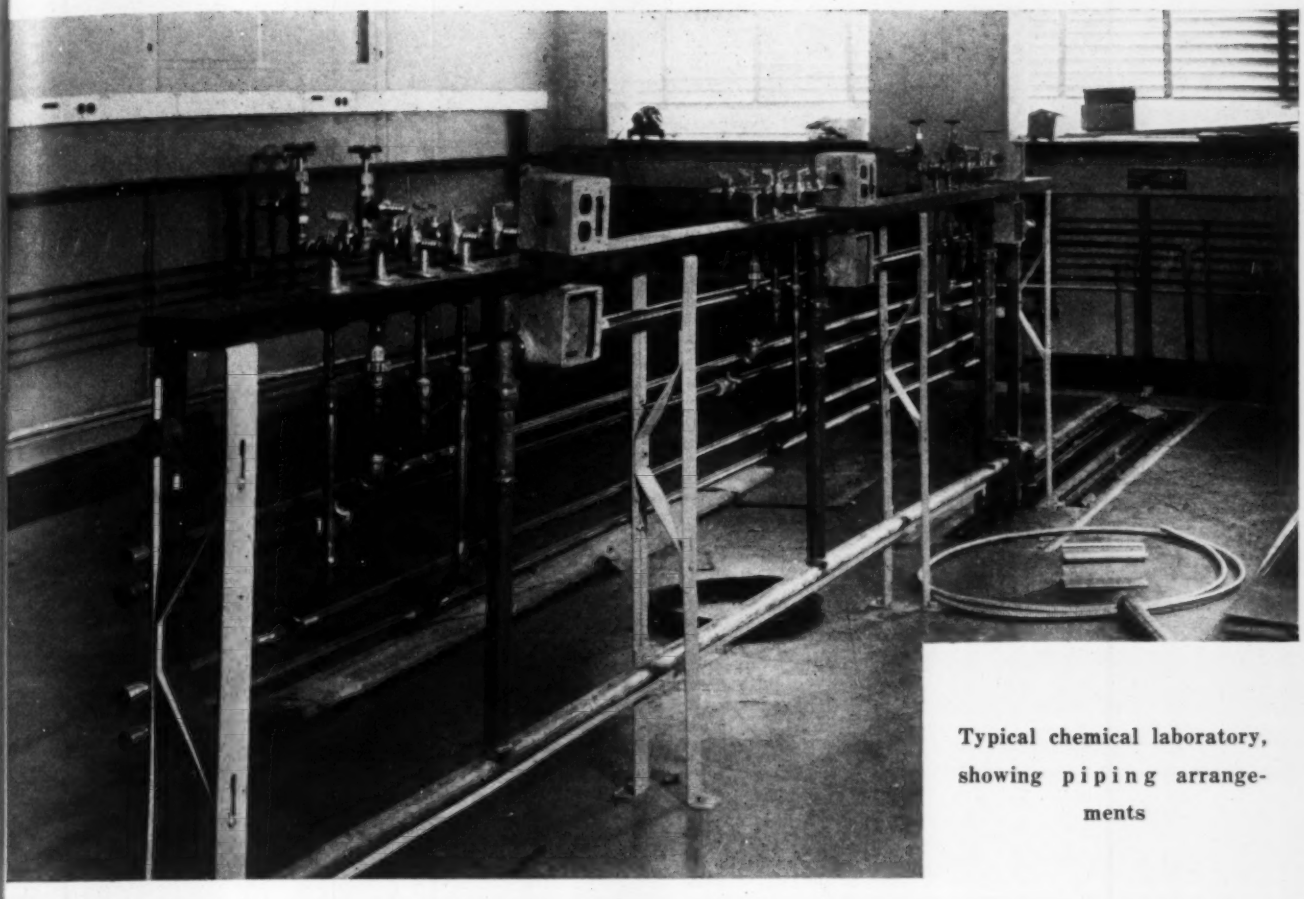
Forced ventilation is provided for the chemical laboratories by blower units which take in outside air, filter and temper it, and force it through ducts into each laboratory room. The air is exhausted through the fume hoods by another set of fans. All of this ventilating equipment is in the attic of the chemistry section of the building.

Supply and exhaust ducts extend vertically from the center line of the attic down to each laboratory below. All supply ducts are galvanized iron but those for the exhaust are ceramic tile pipes, to prevent corrosion by chemical fumes. One exhaust flue is assigned to each laboratory fume hood and a booster fan can be inserted in the line above the attic floor when extra air circulation is required. The exhaust fans maintain the air in the chemical laboratories at a slightly lower pressure than in the rest of the building to prevent fumes from spreading.

There is no centralized air conditioning system for the buildings, but several small conditioning units are supplied from a central cooling system where special laboratory work demands this service. Water for the drinking fountains is also cooled by the same system. The auditorium in



Fifteen different facilities are piped from risers at the outside wall of the building



Typical chemical laboratory, showing piping arrangements

the acoustics building, which is a separate structure, is air conditioned.

Heating System

The plant is heated from a separate boiler house by a vapor-vacuum system with differential control for each of the 10 zones into which the buildings are divided. One or more principal walls with similar exposures are put in the same zone. The radiators in any one zone are controlled by nine resistance thermostats, a windowstat, and a heat balancer.

Steam is supplied by two 225 hp boilers at 125 psi. The mains carry this pressure to the laboratory buildings, 900 ft distant, and then to the distribution points where it is reduced in two stages to 50 and 5 psi. Steam at 5 psi is regularly available in the laboratories and at any other pressure between these limits on demand. There is a radiator under each window.

Outside Piping

Water supply for the entire plant enters the main building through a 10 in. line from the highway, 1000 ft distant. From this building it is carried in an 8 in. main to two 50,000 gal storage tanks at the boiler house, 900 ft beyond.

From these tanks there are two 8 in. mains running back to the main building. One, for house supply, draws from the upper half of the tanks and the other, for fire lines, from the lower half. Thus there is always 50,000 gal of water in reserve for fire emergencies.

To assure adequate water pressure the fire line is connected to a standby pump operated by a gasoline engine. There is a 3000 ft loop of 6 in. cast iron pipe around the buildings which feeds 13 hydrants and standpipes in the building through 10 post indicating valves. The joints on this fire line are bell and spigot, with lug and bolt, caulked with oakum and lead.

The sanitary sewer main is 12 in. vitrified tile pipe. Acid sewage from the chemical laboratory is carried in an 8 in. pipe of the same material to limestone neutralizing tanks and thence to a common pumping station for all sewage, from which it is pumped in a 6 in. cast iron, enamel lined force main to the connection with the local sewer system. Storm water drains of 4 to 12 in. sewer tile carry the water from roof leaders and footing and street drains to open ditches on the property.

The main gas line is 4 in. American Gas Association standard cast iron pipe with bell and spigot joints. It extends 1000 ft from the highway to the main building and 700 ft beyond to the acoustics building.

REFRIGERATION GROUPS DISCUSS WAR PROBLEMS

Members of the Refrigeration Equipment Manufacturers Association met last month in Chicago to discuss wartime problems. Some sessions were held jointly with the National Refrigeration Supply Jobbers Association and the Refrigeration Service Engineers Society.

REMA's president, John Wyllie, Jr., cited in his report the growing importance of the group as contrasted with the individual, for the reason that things are happening these days on such a large scale. He mentioned the need for cooperation now, and during the post war period.

A. B. Schellenberg told the members how the refrigeration and air conditioning advisory committee works. He said there were three stages in the functioning of an industry advisory committee, the first being as an audience or sounding board for WPB officials, the second as a group of critics (which he felt the refrigeration and air conditioning group now is), and the third being as a truly advisory group. There has been recent progress toward this third stage, he said.

Among other features of the program was a discussion of WPB orders affecting refrigeration and air conditioning—including the new L-38 order—by Sterling Smith of the WPB, and a description of how a product group task committee goes into action, by C. M. Cordley. The details of the controlled materials plan of the WPB were also explained.

R. H. Luscombe, Penn Electric Switch Co., was elected president of REMA for the coming year.

HOW TO MEET WARTIME HEATI

CONVERSION FROM OIL TO COAL FIRED STEAM GENERATION

By Samuel I. Rottmayer, Mechanical Engineer, Office of Samuel R. Lewis, Consulting Engineer . . . Presented at Plant Practice Session, Midwest Power Conference

THE PRESSURE of war conditions in restricting the availability of fuel oil has made mandatory the conversion of many oil burning steam generating plants to coal burning, coal being the most available fuel. A host of complications has attended these conversions. Some of these have been general conditions, common to all such changes, while others have been problems highly individual to particular installations. This paper is a discussion of engineering considerations presented by oil to coal burning conversion in a number of cases, as well as an analysis of the adaptability of available equipment.

Types of Coal Firing Equipment

An examination of available coal firing equipment discloses the following general classifications: manual firing, underfeed stoker, overfeed stoker, spreader type stoker, powdered coal.

These types of equipment are adapted to use with steam generators of size range from small to large in the same order in which they are tabulated. However the size of the steam generator is by no means the sole criterion, or even the principal consideration, for selecting the type of coal firing equipment, since the range of sizes to which each classification of equipment may be applied is wide, and since each optimum selection may not have sharply defined limits.

A careful study of many influencing physical conditions must be made for each proposed conversion where there is a choice of firing equipment before a sound selection can be achieved. Then, not of the least importance, the economics of the project must be considered on the common denominator of cost for each proposed type of installation.

Difficulties in Converting

We have encountered many difficulties in converting the usual, relatively small heating systems from oil to coal. Among them are the following:

1) Insufficient combustion chamber cubage. This frequently cannot be remedied because of presence of ground water, and because of probable structural damage from undermining footings of the building.

2) Absence of provision for storage of coal or for getting coal into the building. Frequently the boilers are remote from outside walls and are surrounded by rooms having vital functions in the building services.

3) Absence of facilities for ash removal or storage. The priority restrictions on securing ash conveyors seem more difficult to circumvent than those governing grates and stokers. The prejudice of owners and tenants against ash dust is also a serious barrier against conversion.

4) Chimneys which are large enough and tall enough for burning oil, fail when expected to overcome the resistance of a thick fuel bed. Chimneys surrounded by adjacent tall buildings may serve well with properly adjusted oil burners but are complained of bitterly by the neighbors when discharging coal gases, even though they may permit development of the necessary combustion rate.

5) Labor for manual firing has proved hard to get. In many cases the oil burning equipment operated automatically, and the necessary firemen for handling coal must be located and trained, at considerable expense.

6) We have found local likes and dislikes along political lines a considerable problem. In some communities, for example, oil is easily obtained from the local rationing boards, while in others past grievances as between boards of education and rationing authorities protrude their disconcerting heads.

7) In one large project the PAW decided that it was preferable to allot oil as long as oil is obtainable while the WPB decided that the oil must be saved and proceeded to grant priorities for the necessary materials to convert the system to coal burning.

8) Ownership difficulties are frequently encountered. The tenant may buy the fuel and may operate the boilers, but has no title to the physical property. The owner may allege to be financially unable to bear the cost of conversion. In one case the owner has mortgaged the property to a government agency, and finds that he cannot alter the mortgaged equipment or increase its value by incurring additional indebtedness.

Engineering Aspects of Conversion

Considering only the engineering aspects of converting oil fired plants to coal burning, these may be discussed as applied to the following categories: (I) Small heating boilers, as for residential use. (II) Medium sized steam generators, such as for

TNG & PIPING PROBLEMS

Well-attended by engineers concerned with wartime practice, the Midwest Power Conference held last month at the Palmer House, Chicago, featured papers on a wide variety of power and other problems. . . . We present here three of the discussions which are of particular interest to HPAC's readers — conversion from oil to coal firing, how to break piping bottlenecks, and the Army's fuel and heating program. . . . The conference was sponsored by Illinois Institute of Technology, with nine other colleges and universities and several local engineering groups cooperating, as in other years

commercial and industrial heating plants, and large size steam generators for power generation and process steam uses.

I) In the case of small steel or cast iron heating boilers equipped with domestic types of oil burners, conversion to hand firing usually consists of replacing the oil burner and its refractory lined combustion chamber with cast iron shaking grates and an ashpit door. A draft regulator usually is provided for fire control. This may be either thermostatically or manually operated.

Space must be provided in front of the boiler sufficient to swing a shovel freely and to manipulate clinker tongs.

Where mechanical coal firing is desirable, the common underfeed stoker of the domestic type may be installed with its retort in the base section of the boiler and with the hopper and driving mechanism installed to the rear or at one side of the boiler so as to leave the boiler front clear for easy clinker removal.

It is evident from observation of many installations that no more space was allotted for the oil burning boiler than the bare minimum required to receive the apparatus. The boiler may be closely walled off from the rest of the basement, and to gain space for coal firing a common prerequisite is to move partitions or even to turn the boiler 90 deg. To gain space for coal storage, it may be necessary even to mine out additional basement area where none was provided before.

A bin feed type of stoker may be useful as a space saver by eliminating the bulky coal hopper adjacent to the boiler.

Of course, certain boiler-burner units are designed and built for burning oil exclusively, and conversion to coal burning is entirely impractical.

Thus far, the rationing of fuel oil for house heating has not been critical to the point of requiring conversion from oil to coal firing where excessively heavy investment would be incurred by the owner in making the change. As a consequence, the heating boilers in this size classification that have been converted to coal firing are those requiring very simple and inexpensive operations, or those whose owners have of their own volition authorized the change.

Adequate draft is a vital prerequisite to conversion of any size boiler to coal firing. Especially is this important for small size boilers where it is proposed to fire coal by hand. The available draft created by the chimney must be much greater in the case of coal than for oil, since the added resistance of the fuel bed must be overcome.

An interesting observation which some owners have made is the apparently much better performance of their steam heating system after changing to coal. They are pleased with the freedom from fluctuating temperatures formerly experienced with the cyclic operation of the oil burner. The effect of uniform heat liberation from the mass of an incandescent fuel bed, in maintaining a steady steam condition, in contrast to the intermittent cycling of an oil burner could substantiate such an experience. This would be especially true in the case of an oil burner installation having a relatively small mass of refractory combustion chamber lining which cools quickly by uncontrolled furnace draft.

II) In the case of medium and large size steam generating equipment, such as commercial heating boilers and industrial steam generators, finding space to meet coal firing requirements is considerably more of a problem than in the case of smaller size boilers. With the smaller boiler rooms, disposition of floor space usually is a matter of convenience, whereas in commercial or industrial boiler rooms, each square foot of floor area is represented by an intrinsic investment value. Especially is this true where the boilers are located in metropolitan areas. A description of the problems encountered in a few actual in-

stallations will serve to illustrate these problems and show how they were met.

Some Case Studies

Manufacturing Plant—Case 1 is a manufacturing plant whose depressed boilers are contained between refrigerating compressors to the rear of the boilers, and pumping machinery and the stack to the front of the boilers. The opposite side walls are exterior building walls.

The boilers are internal furnace marine type, each rated at about 133 hp. The furnaces are 42 in. in diameter, entirely too small to permit the installation of manually fired grates. The only known practicable method of burning coal in such boilers is by building brick combustion chambers in front of them, the masonry being thoroughly harnessed in with steel. Maintenance on the refractory linings and arches in such chambers usually is high, and the installation of water tubes or water walls is highly desirable.

In order to gain cubical content for adequate heat release, these combustion chambers must project 9 ft 6 in. in front of each boiler, and should be about 6 ft 0 in. wide and 6 ft 0 in. high. This requires excavation of a pit having its floor about 2 ft below the normal boiler room floor. Water cooling of the refractory, consisting of a 10 in. top header and two 10 in. side headers, joined by about twelve 3 in. water tubes, all circulating water rapidly through connections below the boiler water line, would add about 15 hp to the output of each boiler.

The clinker and ash must be removed from the front ends of the combustion chambers, requiring a minimum clearance for fire tools of about 6 ft. Thus, the boilers, now 15 ft 6 in. long, will, with combustion chambers, fire aisles and minimum clearances, require at least 36 ft of clear length. Thus there is no chance whatever to install adequate combustion chambers and to stoke them, even though manual firing of coal were to be attempted—to say nothing of space for stokers.

There is no space for coal storage anywhere near the boiler fronts. The only space within the building, which at considerable inconvenience and loss of storage space might be partitioned off as a coal bunker, is remote from the boilers across a vitally necessary outdoor exit corridor.

If this storage space were used for a coal room, new coal delivery chutes could be cut through the exterior wall, and new partitions could be built to keep the coal dust from entering adjacent manufacturing areas and laboratories which must be kept dustfree. A coal elevator and overhead conveyor could transport coal from this room to the boiler room.

The only means of securing the necessary length for the boilers, combustion chambers, and stokers is by turning them 90 deg, excavating, and extending the building. An alternate and preferred location for the coal room would be a similarly excavated room in front of the boilers and combustion chambers with a concrete cover through which coal could be dumped from trucks. The latter plan would lend itself well to mechanical firing with bin feed underfeed stokers. Ash could be stored in part of this new room, and hoisted by an electric winch to deliver to trucks.

The war production in which the plant is engaged, as well as the manufacturing technique, necessitates a continuous supply of steam throughout every 24 hr. The reconstruction can and must be scheduled so as to allow one boiler unit to be placed in full operation with coal while the second boiler unit, oil fired, is serving the load. After the first boiler unit has been cut into service, the second boiler unit can be turned 90 deg, equipped with combustion chamber and stoker, and tested.

The investment cost for this conversion is approximately $28,000, of which more than half is building reconstruction. If the boilers were outside of the building, the space occupied by them would be very useful for additional machinery, giving a dustless engine room. The conclusion presents itself that it would be highly desirable, if financially practicable, to provide an entirely separate boiler house, efficiently designed for coal firing, with underground pipe mains connecting to the main building.

Club Building—Case 2 is an athletic club building, situated in a metropolitan district, whose low and wide bent tube, water tube boilers are several stories below grade. The load on the plant fluctuates widely, from about 65 to 500 hp.

Space limitations for coal storage were overcome by building a hopper bottom in an elevator shaft, and lining the sides with asbestos cement board. Coal is spouted to the stoker hoppers.

A pneumatic spreader stoker is well adapted to a wide range of load. This consists of a coal preparation or crusher unit which receives coal by gravity from the hopper bottom, crushes it, and conveys it pneumatically to two nozzles discharging into the combustion chamber above a grate. With two nozzles and automatic control of the coal preparation unit, there would be no loss of ignition even at the light loading. Another form of a similar coal burner employs forced draft and uses rapidly whirling hammers which spray the crushed coal over the grate.

Due to the characteristic of this type of combustion, in which the coal burns largely in suspension, there is always a flyash problem, especially in the dust from the chimney top. Soot blowers and possibly a flyash separator in the breeching would be required with these types of coal burners.

Two low clearance underfeed stokers were installed side by side, separated with a longitudinal refractory bridge wall. These meet the wide range in load requirements for this plant, with good maintained efficiency, with minimum sacrifice of combustion chamber volume, and with no flyash problem.

Three Plants—Case 3 is an illustration of expediency. Three manufacturing plants, formerly burning oil, were served from rejuvenated, formerly abandoned, coal fired steam generators situated on the property of one of the three plants. The old water tube boilers were rebaffled with plastic, absolutely tight barriers; the old underfeed stokers were overhauled; mechanical coal handling was provided from an outdoor storage pile; and steam and condensate return were piped above ground to the three factories. Permission was obtained to run across an intermediate property to serve one of the three factories.

Church Group—Case 4 is an example of a logical conversion of oil fired steam generators which was concluded under pressure of wartime fuel oil restrictions. Two churches, three dormitories, and three residences all within a few hundred feet of each other and of the underground steam distribution system of a large private institution, were changed to central station service from the underground mains. It was thus possible for eight condensation meters to eliminate eight oil burners.

Stoker Capacity and Fuel Consumption

We find that about 20 sq ft equivalent direct radiation may safely be used per pound of Illinois coal in selecting stoker capacity. Thus a plant requiring a boiler rated at 10,000 EDR may be served by a stoker which burns 500 lb per hour of coal.

In many cases where there are two oil burning boilers, it is apparently expedient to leave the oil burning equipment under one boiler and to install a stoker or manually fired grates under the other boiler.

In estimating the comparative fuel consumption for coal as compared with that for oil it is necessary to assume the relative efficiencies since rarely are there obtainable quickly the data on seasonal loads. Generally for small residence plants we have assumed 60 per cent for oil and 50 per cent for manually fired coal. With larger boilers, such as are installed in institutions, we have used 75 per cent efficiency for oil and 65 per cent efficiency for coal.

The accompanying chart sets forth comparisons at various efficiencies.

Millions of Btu Utilized per Ton (2 000 Pounds) of Coal

Gallons of Oil

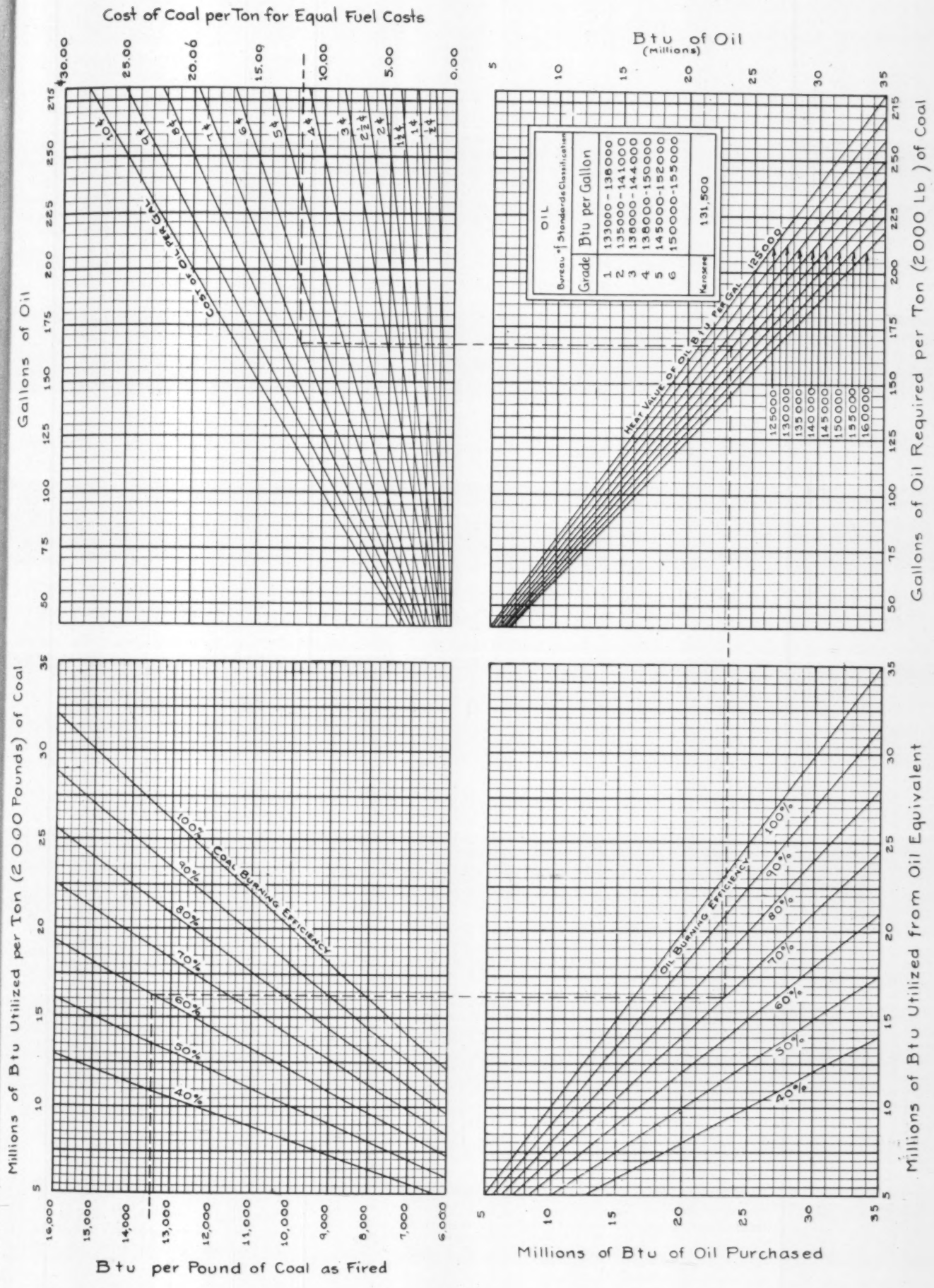


Chart for determining equivalent fuel costs with coal and oil
(Copyrighted by Kewanee Boiler Corp. and reproduced by permission.)

Thus, following the dotted line through the four charts commencing at the lower left corner, a pound of 13,500 Btu per lb coal at 60 per cent efficiency to oil at 70 per cent efficiency to heat value of oil per gallon to cost of oil per gallon, the cost of coal per ton for equal evaporation and the gallons of oil may be read.

The following is an ordinary equation useful in computing relative fuel consumption:

$$\frac{\text{Btu per gal of oil} \times 0.75}{\text{Btu per lb of coal} \times 0.65} = \text{lb of coal per gal of oil.}$$

Thus if the oil has 148,500 Btu per gal and the coal has 11,000 Btu per lb and if the oil consumption per season was 12,000 gal, then

$$\frac{148{,}500 \times 0.75}{11{,}000 \times 0.65} = 15.6 \text{ lb of coal per gal of oil}$$

and

$$\frac{12{,}000 \text{ gal of oil} \times 15.6}{2000} = 93.6 \text{ tons of coal}$$

The Question of Cost

Under ordinary conditions the owning and operating cost of a steam generator is analyzed carefully, evaluating all factors and features of the coal burning and the oil burning design of the plant. The lowest total cost thus determined usually influences the selection of fuel. Investment costs of new plants, so designed and built, fall within standard and acceptable limits.

The investment cost for conversion of an existing oil burning plant to coal burning, however, usually has no precedent or basis in economics, since the conversion is dictated by wartime necessity. This condition has created new financial crises both for individuals and for communities.

The following is offered as an illustration of investment costs of conversion from oil to coal for six large schools, long accustomed to burning oil, in a small city in Illinois:

No. 1	$ 7,850
No. 2	6,100
No. 3	3,900
No. 4	4,010
No. 5	9,275
No. 6	4,825
Total	$35,960

The board of education in this case was faced with raising close to $40,000 when engineering and extra labor and incidental expenses are considered, this unexpected investment not having been allowed for in the budget.

The conversion from oil to pulverized coal firing in steam generators of large size, such as are found in central stations for power generation and in large industrial plants, has been described very completely by Mr. Hardgrove in a paper given at the fuels and steam power meeting of the American Society of Mechanical Engineers in March.

Many steam generators of this size classification originally were designed to burn oil or pulverized coal, whichever was the more economical or available; or if the firing equipment for only one fuel initially was installed, the furnaces were designed to facilitate simple conversion to the other fuel. With these steam generators, few if any difficulties attended the discontinuance of oil for fuel.

With steam generators originally designed to burn oil exclusively, however, firing with pulverized coal usually can be done only at reduced output. Higher ratings from these boilers can be obtained only with higher furnace temperatures and with pulverized coal firing, this is accompanied by slagging difficulties. The use of high fusion ash coal, if economically available, may not be sufficient to develop the original output.

If reduction in capacity of the unit is not acceptable, one or more of the following prescriptions may be indicated.

1) Use of a large quantity of excess air for combustion. This air is most effective if it is introduced through well located ports in the furnace walls rather than through the burners, but inevitably must result in a lowered efficiency.

2) Use of recirculated flue gases to keep the furnace temperature below the fusion temperature of the ash. The furnace temperature can be varied in inverse proportion to the percentage of flue gas recirculated, but the power expenditure for driving the recirculating blower results in a reduced efficiency.

3) The furnace may be redesigned to provide additional water cooled surface. This heat absorbing area will be gained to attain the desired steaming capacity at normal efficiencies with furnace temperatures that can be tolerated.

While the first two plans may be used as temporary expedients, it is judicious to plan all conversions as permanent, efficient installations for conservation of fuel.

BREAKING BOTTLENECKS IN PIPING MATERIALS

By G. W. Hauck, Manager of Engineering Sales, Crane Co. . . . Presented at Session on Plant Maintenance, Midwest Power Conference

THE ADVENT and continuous use of higher pressures and temperatures in power plants and manufacturing processes during the past decade or so has been accompanied by a corresponding increase in the use of steel in piping materials. As a result, to serve these elevated operating conditions, steel initially, and of necessity, superseded the cast irons as a suitable metal in material specifications. Almost concurrently, there was developed a gradual but definite preference for the use of steel instead of cast iron to take advantage of the greater strength of steel even in those services where the basic requirements of pressure or temperature did not suggest the use of the stronger metal.

In time, the increased production of steel progressively reduced its cost in those materials finding extensive use in piping systems. Ultimately, the differential in the costs of steel and cast iron became low enough to further accelerate the use of the better material of greater strength. This was particularly true of flanges.

Use of Steel Flanges

The use of steel flanges, therefore, on the bulk of the lines comprising piping systems, has become accepted practice. The advantages of an unbreakable flange of the same material as the pipe appealed to users because it eliminated failures due to the breakage of cast iron flanges in transit, in handling, or, at times, in the severer operating services. This was particularly true in the larger sizes of flanged joints. Thus, steel flanges found their way into saturated steam lines and all sorts of low pressure services. Steel became the order of the day as the material for flanges used on most steel and wrought iron piping. The age of steel found piping keeping pace.

At one time, lap joints were available with the flanges made of a va-

riety of metals—cast iron, semi-steel or ferrosteel, malleable iron, cast steel, and forged or rolled steel. For the past decade, however, the production of lap joints has been confined almost exclusively to the use of steel flanges in general practice. The cast irons and malleable iron were practically abandoned as suitable metals for the flanges.

When welding came into widespread use as a method of making pipe joints, it had a marked and an important influence in giving impetus to the swing from iron to steel flanges. Steel flanges are required in accepted practice when they are to be attached to steel or wrought iron pipe by welding.

Developments in the refining and process industries found additional uses for steel flanges. They prove ideal for those pipe lines where fire hazard legislates against the use of cast iron. Certain services in these and similar industries also made the use of welded flanges desirable.

War Demand Creates Shortage of Steel

Thus we have traced and reviewed the principal factors responsible for the widespread use of steel flanges on much if not almost all of our piping work. This has created a bottleneck in steel flanges, a condition that has been apparent for some time, and seriously aggravated by unprecedented war demands that now make it acute because the steel required to make such flanges is desperately needed for other war production requirements. We just don't have enough steel for everything, and flanges do not escape the critical shortages. This means that users are faced with the dilemma of finding a way to bypass the shortage of steel flanges. The only apparent solution is to suspend the general practice of using steel flanges for all services. Instead, we must revert to our former habits of using steel only where service conditions make its use mandatory. For all other services, cast iron flanges, which are usually available, make an acceptable alternate. A consistent effort by all users to spread the available supply of steel flanges over a wider area of essential needs only, and using the alternate cast iron flanges in every possible service, will contribute materially to the war effort during the emergency when steel must be conserved.

Advantages of Cast Iron

From the foregoing, it is apparent that a recommendation outlining the services where cast iron flanges are satisfactory is in order. Cast iron screwed flanges and cast iron lap joint (van stone) flanges are available for operating conditions which do not exceed 250 psi saturated steam pressure and in most cases where the service does not exceed 450 F maximum.

Cast iron screwed flanges are available in a wide range of sizes, in the 125 psi and 250 psi pressure classes. The screwed flanged joint, properly made, has proved its general utility and satisfactory performance within its pressure and temperature limitations. If prefabricated piping is purchased, an added advantage can be gained by specifying the refacing of screwed flanged joints. In this process, the flange is made up tight until the end of the pipe projects slightly beyond the face of the flange. A light refacing cut is then taken across the face of the flange and the end of the pipe. This provides an excellent gasket bearing surface to the inside of the pipe because the end of the pipe is flush with the face of the flange. Refacing also produces perfect alignment of the flange face at 90 deg with the center line of the pipe, and makes for easy bolting without stresses.

Lap Joints

Again lap joints (van stone) are available with cast iron flanges in a range of sizes from 2 to 24 in., inclusive, in both the 125 psi and the 250 psi pressure classes. These can be obtained to best advantage when the quantities of various sizes are sufficient to justify production.

Cautionary Suggestions

Thus, the use of cast iron instead of steel makes available the lap joint for many services where this type of joint with its advantages is preferred. But an important cautionary note is necessary. Care must be exercised in bolting up any lap joints equipped with a cast iron flange in order to prevent breakage. Pipefitters are accustomed to finding all lap joints with steel flanges, and they cannot apply extremely heavy bolt loads or sledge bolts when cast iron flanges are employed.

Several additional cautions are suggested:

1) Cast iron flanges should never be used on the ends of any type of expansion pipe bend. Such flanges, as well as those on the piping adjacent to the expansion pipe bends, should always be of steel to preclude breakage.

2) Cast iron flanges are not recommended for lines handling hazardous fluids, or where fire hazard legislates against their use.

3) Do not exceed code limitations concerning pressure and temperature in using cast iron flanges.

Other Materials Are Affected

A consideration of bottlenecks in piping materials and suggestions for alternates or substitutions cannot be confined to flanges alone. Many other items comprising piping systems are affected by the shortages and limitation orders that are current today and which plague designers, manufacturers, purchasers, and erection or maintenance crews. The list of alternates or substitutions contained in the following paragraphs is not intended to be all-inclusive, but simply to focus attention on the necessity for a realistic attitude in thinking about the standards of installations and materials for the various components of any piping system. Shortages of materials and long deliveries on many items commonly used should throw into bold relief the need for flexibility in specifying requirements, attended at all times by a willingness quickly to revise plans to accept alternates or substitute materials which may be available at the time and which will do the job with sufficient satisfaction to justify the change.

To adhere strictly to hard and fast specifications and to ignore the exigencies of the day is to invite costly delays and often an unnecessary expense in expediting articles not in stock or difficult to obtain while satisfactory substitutes rest in the stock bin, or at worst could be produced in shorter time.

Unions

Just as the age of steel found flanges keeping pace, so it is with unions. A few years ago the advent of relatively low priced steel unions persuaded many users to adopt them in preference to malleable iron unions. As in the case of flanges, there ensued a marked preference for the use of unions made of steel instead of iron to take advantage of the greater strength of steel even in those services where the basic requirements of pressure and temperature did not suggest the use of the stronger metal. The advantages of a union made of an unbreakable material and of the same material as the pipe appealed to users.

Because steel is needed for other war production requirements, there are shortages of steel unions and often they are not available when needed, even on the most important piping projects. In many instances, the shortages can be sidestepped by reverting to the former practice of using malleable iron unions whenever the service conditions permit their use. Specify steel unions only when the pressure or temperature conditions require them or if the nature of the liquid or gas in the pipe line would preclude the use of any union other than one of steel.

Small Fittings

Again, just as in the case of flanges and unions, and for the same reasons, small fittings of steel superseded those made of cast iron or malleable iron in parts of piping systems. Again, shortages of steel fittings can be bypassed by reverting to former practices. Conserve steel by

using more cast iron and malleable iron screwed fittings—they are made in several pressure classes and provide satisfactory service for many lines, with the added advantage, at present, of being more readily available than steel fittings.

Small sizes of forged steel fittings are made today with screwed ends or socket welding ends. For certain services, users found it desirable formerly to seal weld the joint made by screwing pipe into a threaded steel fitting. This was partly, if not largely, responsible for the development of the steel fitting with socket welding ends, which has advantages over the screwed fittings when the joint between the fitting and the pipe is to be welded. Thus, we normally find two types of small steel fittings—screwed end for the threaded joints, and socket welding end for the welded joints.

But when shortages of steel preclude maintenance of consistent stocks in both types, a construction program might be accelerated by the acceptance of either type or a combination of both types in the assorted sizes and variety of fittings needed in a job. Even though the socket welding fitting is better than the screwed fitting with a seal weld, the latter is merely a reversion to a practice formerly followed satisfactorily. Conversely, a job may normally require screwed steel fittings and, if they are not available when needed, the substitution of socket welding fittings, if obtainable, is the answer to that dilemma. And, a mixture of both types of fittings in the same line, while not 100 per cent mechanically correct or perhaps in tune with a standard in a plant, might solve a vexing and costly delay in construction.

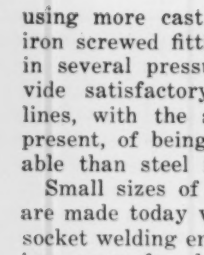
Small Steel Valves

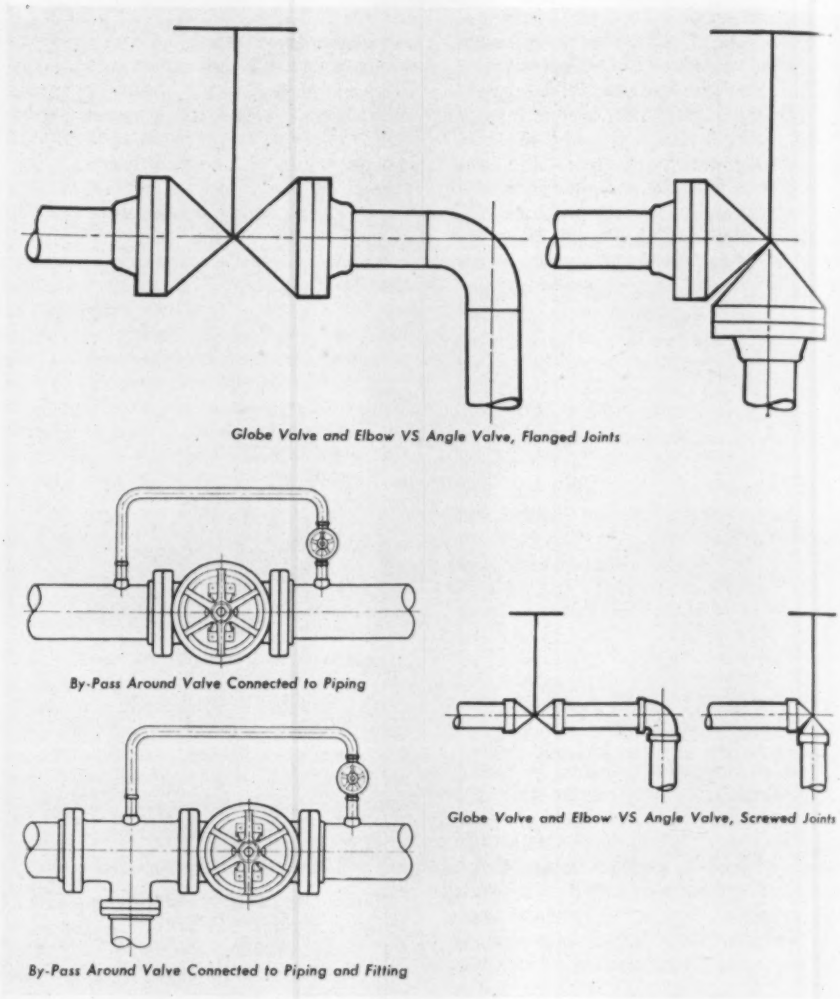
The suggestions in the preceding paragraph apply with equal force to small steel valves which are made with socket welding or with screwed ends. A willingness to use either type of end connection, or an assortment of both, may pay dividends in time saved.

In some cases it may be the practice to use small steel valves with flanged ends. If some day you find that flanged valves, or the flanges, or the studs, or the desired gaskets (it takes all of these to make this flanged installation) are not available when needed, check to learn if a socket welding end or a screwed end valve can be used.

Don't Overlook Angle Valves

Globe valves are used to a much greater extent than angle valves. The demand for valves today means that the stock bins for globe valves may be empty while the bins for the corresponding angle valves may contain the answer to that immediate need. Globe valves are used in straight lines of pipe, but almost all piping contains "turns." Often a "turn" is not far from the place where the globe valve is to be installed. An angle valve could be used here to take the place of the globe valve and the "turn," and eliminate one joint. In very few instances can fault be found with such a substitution.





Globe Valve and Elbow VS Angle Valve, Flanged Joints

By-Pass Around Valve Connected to Piping

Globe Valve and Elbow VS Angle Valve, Screwed Joints

By-Pass Around Valve Connected to Piping and Fitting

Bypasses on Valves

A bypass is a "must" for many valves. While valves with bypasses are listed in a wide variety of sizes and pressure classes, the predominant demand and the resultant production is for regular valves without bypasses. To attach the bypass, which involves extra labor operations, may delay procurement of a valve with a factory built bypass. While suffering from this delay, a regular valve often may be obtained in much less time. Possibly the installation is such that the bypass can be constructed independently of the valve and around it by providing connections in the adjacent pipe or fittings and constructing the bypasses on the job. *Caution:* When constructing bypasses around valves, be sure to provide flexibility in the bypass piping to compensate for expansion stresses.

If the materials for constructing the bypass are not at hand, it might be practical to install the valve and "limp along" until such time as the bypass materials are secured and installed.

Wedge Disc or Double Disc?

A few classes of gate valves are regularly listed in both the wedge disc and the double disc types. Users have developed preferences for each over the other, but in many instances one type can be substituted for the other without detracting from the effectiveness of the installation.

Valve Stem Packings

All valves are regularly equipped in the factory with valve stem packings that are suitable for general service in keeping with the pressure, temperature and operating conditions for which various valves are rated. It follows that valve stem packings are individually and carefully selected to provide a standard of satisfactory service. Valves are carried in stock only with the valve stem packings adopted as standards.

When every effort is being devoted toward the manufacture of valves in the greatest volume which is possible to meet abnormal demands, it is apparent that an order for valves to be equipped with a packing other than that regularly provided would mean a break in production. Costly delays ensue for both the manufacturer and the user. It is far better to discard any predilection for a specific pack-

ing when such a choice interferes with normal procedures and the possible slight advantage can only be gained at the price of delay in procurement. Even when a special packing must be used for unusual service conditions, it is suggested that regular valves be obtained and the procurement and installation of the desired packing accomplished by the user subsequently.

Special Valve Operators

Special valve operating devices, such as floor stands, hydraulic cylinders, gears, air motors, electric motors, etc., normally are ideal from a mechanical or operating standpoint for specific installations. Under current conditions, however, specifying a regular hand operated valve will speed up deliveries and the completion of projects. Use the special operators only when absolutely essential and when no substitution is practical. Perhaps the installation is such that hand operation will suffice until the special operator wanted is more readily obtainable at a later date.

Screwed, Flanged, or Welded Joint?

Embracing all items of valves, fittings, fabricated piping, etc., the type of end connection or joint must be kept in the foreground of the thinking of those who are alert to break construction bottlenecks. For instance, if shortages involve flanged connections, perhaps a screwed or a welded connection is the answer to the problem. Perhaps a flanged valve or fitting is available, but the flanges or the studs are not. Can a welding end valve or fitting be used? It just might mean the saving of valuable time. Such thinking and flexibility in making substitutions may prove helpful many times.

It is not uncommon to find many plants which have a standard of piping construction that calls for two or more types of joints in the various sizes of pipe lines in the same service. As an example, on certain lines, screwed joints are used in sizes 2½ in. and smaller and flanged joints in sizes 3 in. and larger. The next project may disclose that some of these 3 in. or 4 in. or 6 in. flanged fittings, or the flanges, may not be in stock at the moment. The substitution of screwed fittings is worthy of consideration. Or, perchance, a welding fitting could be used satisfactorily. Or, a fabricated pipe bend or assembly might circumvent delay.

Fabricated Piping

That flanged elbow with a special dimension at one end, or that flanged tee with an elongated dimension on the run, or that special base elbow, can be difficult if not impossible of procurement because it involves pattern work, special machining and handling, etc. Inquiry may disclose that this problem can be solved by the shop fabrication of a piping assembly. Special tees can be made by welding the outlets in pipe and providing flanged ends, threaded ends, or ends beveled for welding. Bases can be applied by welding.

Pipe bends can be used for turns, offsets, and for accomplishing all sorts of changes in direction. The variety of shapes into which pipe can be bent suggests interesting possibilities.

The same holds true for welded headers with multiple nozzle openings, drip pockets, tapped bosses, etc., or for welded assemblies. Reductions in sizes can be accomplished by swedging, and end closures can be fabricated by welding. And so it goes.

WAR WORKER'S PLEDGE TO A SOLDIER

"I will never let you down. My life is in your hands. Your life is in my hands. I will work to make the best and the most of the things you must have to win—that we both may live—that our country may live—that freedom for all may live."—(Pledge taken by workers at a General Electric Co. plant at a recent Army-Navy "E" award ceremony.)

The almost unlimited range of possibilities created by the use of prefabricated piping should occupy a prominent place in the minds of those who are intent upon overcoming delay and breaking bottlenecks.

Bolting Materials

Having previously described the trend toward an increased use of steel in other products, it is well to direct attention to a concurrent trend toward the application of alloy bolting materials in flanged joints when the actual operating conditions do not necessarily require this class of product.

Commercial steel bolts or studs are recommended for temperatures up to 500 F. Alloy studs are needed when temperatures are above 500 F. The prevalent scarcities of alloy steels dictate the installation of commercial steel bolting material whenever it can be used. Enough installations of 150 psi and, to some extent, of 300 psi steel materials are for services which permit the use of commercial bolting to justify the inclusion of this suggestion.

If You Weld

The plant which has adopted welding as the exclusive tool for making piping joints may be experiencing difficulties because some type of welding flange is not available for making flanged connections to valves or other equipment. Perhaps the substitution of screwed flanges is impossible because equipment for threading the pipe is not available.

If a cast iron flange can be used, as outlined previously, then a flanged connection can be provided for attachment by welding through the use of welding nipples made up with a refaced screwed flange on one end and machine beveled for welding on the other end.

The welding elbow needed may not be readily available, as may happen in the case of those made with a wall thickness or of a material not regularly carried in stock. A beveled end pipe bend made from pipe of the desired thickness or material sometimes can be fabricated and save time. The pipe bend would have longer center to end dimensions, but many times that presents no particular problem.

Piping Ingenuity Pays Dividends In Time Saving

A few simple substitutions are listed herein to illustrate how a little ingenuity can solve many everyday problems of shortages.

A reducing screwed flange often can be made by tapping a blind flange, either concentric or eccentric as desired. This is practical, provided the tapped opening is not too large in pipe size to preclude a sufficient length of thread for a satisfactory pipe joint.

A piece of plate, if available, can be fashioned into a slip on welding flange or a lap joint flange if the thickness is increased, particularly in the latter, to compensate for the lack of hub. Similarly, a blind flange can be fabricated from steel plate. These are not recommended necessarily as good practice, but they are satisfactory in certain instances, especially in emergencies.

Instead of a 4x3 in. screwed elbow required for an extension of a pipe line during a shutdown, perhaps a 4x3x3 in. screwed tee with a 3 in. plug would answer the purpose. If this happened to be a flanged job and the reducing fitting were not in stock, would a straight fitting and a reducing flange suffice? If it were a welded job and the reducing fitting unavailable, would a straight fitting and a reducer satisfy the need? Generally, the answer will be in the affirmative.

Today the bushing comes into its own as never before. Many sizes of reducing screwed fittings have been eliminated due to the simplification program. At other times, the desired reducing fitting may not be available. Use the nearest size of reducing fitting or a straight fitting with bushings to break these bottlenecks.

It is well to repeat that the list of substitutions suggested herein is not all-inclusive, nor is it intended to hold any brief for some of the constructions suggested in the substitutes. They do not always por-

tray the most desirable practice from a mechanical or a standardization viewpoint. But shortages and the necessity for maintaining speed by circumventing the attendant delays require users of piping materials to be opportunists and extremely flexible in their thinking at all times. Only in this way may you be able to salvage a bit of leisure time and save embarrassing explanations for delays.

THE FUEL AND HEATING PROGRAM AT ARMY CANTONMENTS

By Lt. Colonel Louis C. McCabe, Chief, Heating and Refrigeration Section, Repairs and Utilities Branch, Construction Division, Office of Chief of Engineers, U. S. Army . . . Presented at Army Engineering Hour, Midwest Power Conference

NO DISCUSSION of the fuel and heating program as it applies to the Army within the continental United States would be understandable without some knowledge of the organization within which it operates. The three component parts of the Army under the Chief of Staff are the Air Forces, Ground Forces, and the Service Forces. The job of the Army Service Forces, in the words of the Commanding General—Lt. General Brehon Somervell—"is to feed, clothe, house, pay, equip, and transport the Army. We care for the soldiers when they are ill, we judge them when they misbehave, we build camps and roads. We put into their hands, wherever they are, their guns and ammunition, trucks and tanks. We order this material, make sure there are factories to produce it, see that they work efficiently and are provided with sufficient raw materials."

The Chiefs of Chemical Warfare, Engineers, Ordnance, Transportation, Chaplains, the Quartermaster General, and the Adjutant General direct their services as staff members of the Commanding General, Army Service Forces. The continental United States is divided into nine Service Commands, each commanded by a General Officer who is the representative of the Commanding General of the Army Service Forces. His staff is composed of representatives of all the services.

The Corps of Engineers has the job of building and maintaining all posts, camps, and stations and providing them with utilities. General planning and supervision of these activities is the responsibility of the Chief of Engineers. In each Service Command the Division Engineer has responsibility for all military construction. As the Director of Real Estate, Repairs, and Utilities, he directs the purchase and leasing of facilities for training and housing troops and when the facility is activated, he appoints a Post Engineer, who maintains the buildings and grounds, and provides the utilities—electricity, refrigeration, water, sewage disposal, fuel, and heat. It is with the furnishing of fuel and heat that this paper is concerned.

Types of Heating Used

Buildings heated at Army cantonments are in four general classifications: (1) permanent, of brick and stone construction; (2) mobilization type—mess halls, hospitals, and barracks of wood construction, which was a standard until a year ago; (3) theater of operations type, which is a composition board and of less durability; and (4) tents and hutments.

Permanent buildings are usually heated from a central plant with coal, oil or gas. In officers' quarters of the permanent type, where coal is used as a fuel, domestic stokers may be installed.

The mobilization type barracks building is heated by a forced warm air furnace, the heat being distributed over both floors of the building by a duct system. Gas and coal are the usual fuels, although oil in small quantities is employed. Soldiers are assigned to firing furnaces of this type which burn coal. It has been found that in some areas less than half of the soldiers had previously seen a warm air furnace. This condition made it imperative that some satisfactory method be developed for firing the furnaces and maintaining the automatic controls. It was first planned to assign service troops permanently to firing duties, but the demand for their services was so great in military activities that this could not be approved. Consideration was given to the use of civilian firemen entirely, but the cost prohibited this. In the plan finally adopted, experienced civilians are assigned to the supervision of operation and maintenance of each 35 furnaces. Soldier personnel is assigned to fire furnaces. This plan has been remarkably successful in reducing maintenance and repair costs.

All steam plants of more than 100 hp are fired by civilian employees regardless of the type of building. In all instances, supervision and training must be continuous.

All types of mechanical stoking equipment are installed in central plants over 150 hp—multiple and single retort underfeed, traveling grate, and spreader. Pulverizers have been installed in some of the larger plants and more are replacing oil burning installations. More than 70 per cent of the oil burning installations have been converted to coal.

Controls and Instruments

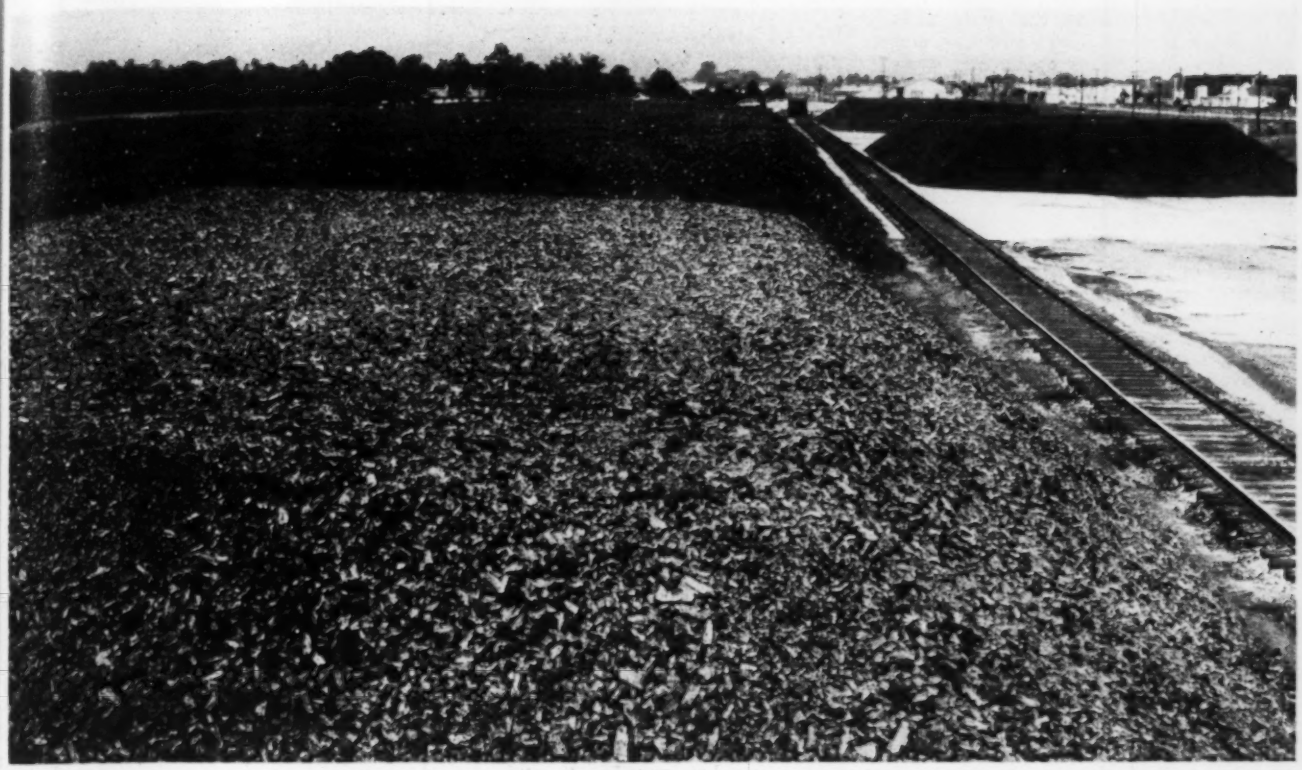
It is the policy of the Chief of Engineers to provide draft gages on all boilers of 100 hp and larger, one steam flow meter on each boiler of 300 hp and larger, one steam flow meter on the main header from a group of boilers where individual meters are not used. Steam flow-air flow meters may be installed in lieu of a steam flow meter and CO_2 recorder in boilers of more than 300 hp. One combination CO_2 and flue gas temperature recorder is authorized for each boiler of more than 300 hp. Automatic draft controls are authorized for all boilers of 150 hp and larger.

Installation of this equipment has been of great assistance in maintaining operating efficiencies even with inexperienced personnel. However, at one post down in the pine country of Georgia where all these controls had been installed in a hospital, the operating engineer (who had formerly fired a sawmill boiler) came to the Post Engineer and requested permission to make some changes in the installation to get away from operating troubles. His solution was to pull out the stoker, remove the control instruments, install grates, and fire the 450 hp boilers with slab wood and sawdust.

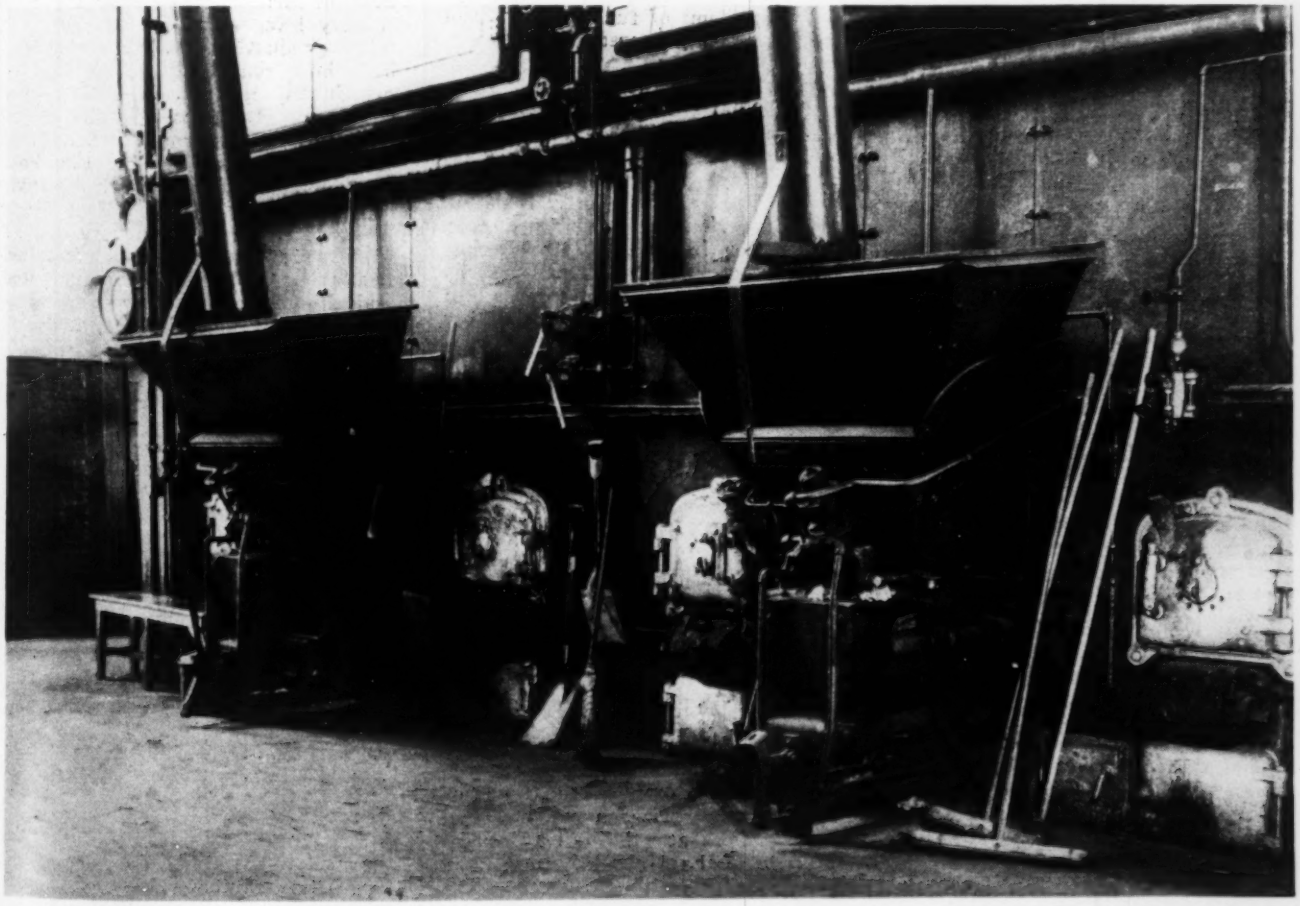
Combustion service as practiced by the Army falls into three categories: (1) education through conferences and schools; (2) inspection designed to establish proper operation and preventive maintenance; and (3) trouble calls.

Training Program

The Chief of Engineers, the Division Engineer, and the Post Engineer all have trained personnel qualified to carry on the activities of their echelons. The magnitude of the program and the shortage of manpower precludes the employing of the personnel required on all occasions. Supplementing the Army in this effort are a number of private and government agencies which devote considerable time to the heating problems of the Army camps. The Anthracite Industries, Inc., was the first in the field and provided some 15 engineers who conduct schools in proper firing in the northeastern posts where an-



Above—A view of section storage, "coke, egg and stoker coal," at a southern camp. The height of the coal piles is 18 to 20 ft. The coal is piped for temperature readings. . . . Below—These are two boilers at an eastern military installation which have been converted from oil to coal (Signal Corps photo)



thracite is commonly the fuel. This assistance is continuous and has materially reduced the operating costs of anthracite burning equipment.

Bituminous Coal Research, Inc., has recently made available to the Division Engineers some 60 combustion engineers of national reputation who devote considerable time to conference and schools, inspection and trouble calls at Army posts.

These organizations supplement the small staffs of the Chief of Engineers, the Division Engineer, and the Post Engineer. There is in the Washington office an engineer who has broad experience in warm air heating and is particularly gifted in talking the language of the mechanics and soldier firemen. On one occasion last fall, he was talking furnace firing to a theater full of soldiers. It was his theory that one or two spicy stories inserted during his talk served to keep the audience interested and awake and he had followed this practice in his round of the camps. However, this particular post commander was very enthusiastic and had all officers of the rank of captain or below attend the lectures of this expert on furnace firing. This included the post chaplain, who after the talk suggested that the engineer delete the stories from future instruction. The post commander thought that this would be one line of procedure but he also suggested that in the future before the engineer began to talk, he might inquire, "Is there a chaplain in the house?"

During the past year the Chief of Engineers directed and the Signal Corps produced a film strip which provides standard instruction for the firing of coal burning furnaces throughout the Army. Copies of this film strip have been distributed to all coal burning posts.

Water and Coal Analyses

The U. S. Bureau of Mines has, for more than a year, provided water analysis service for all boilers greater than 15 psi pressure. A sample is forwarded to the Bureau each month from each boiler. As a result of the analyses, recommendations are made for proper treatment to prevent corrosion and scaling. This service has greatly reduced replacement of tubes and provided economy in fuel consumption. It has recently been expanded to large low pressure cast iron boilers, which are installed in recent construction in lieu of high pressure plants.

The Chief of Engineers is responsible for the quantity, specifications, provision of funds, receipt, storage, and distribution of coal at all Army posts. The Quartermaster General is responsible for purchase and inspection of the coal. The latter function is delegated to the Chief of Engineers. Arrangements have been made with the Bureau of Mines for sampling of all coal going to Army camps. Sampling was previously done at the post by soldier personnel and considerable difficulty was encountered because of improper sampling methods. It is anticipated that the Bureau of Mines sampling will eliminate these troubles and will greatly reduce the cost of sampling, necessary to a satisfactory fuel supply.

Purchase of Fuel

The Army is one of the largest consumers of fuel in the United States. The aggregate of hundreds of camps containing thousands of buildings, each of which requires fuel for space heating, cooking, water heating, or process steam presents a fuel demand and a fuel problem of great magnitude. Fourteen camps use more than 100,000 tons of coal annually and 32 camps use between 50,000 and 100,000 tons annually. The Army will use between 8 and 9 million tons of coal in the fiscal year 1944. Seventy-seven per cent of the fuel requirements are coal, 18 per cent natural gas, and 5 per cent oil and miscellaneous fuels.

The problems of fuel selection, fuel specifications, procurement of funds, inspection, receipt, storage, and delivery of fuel, and heating plant maintenance, require most careful planning and execution. One of the major problems has been the proper allotment of fuel for these purposes. Too small a fuel allotment may result in sudden overload demands for fuel in winter, too large an allotment may result in carelessness in use, loss by spontaneous combustion, overload of limited storage space, and unjustified inroads on the industrial and domestic supply. The problem is complicated by the fact that camps are situated in areas with all gradations between year 'round heating and short seasonal heating, that almost every available type of fuel is used, that the personnel changes continuously, that every type of heating equipment is used, and that buildings ranging from permanent hospital structures to tents are heated.

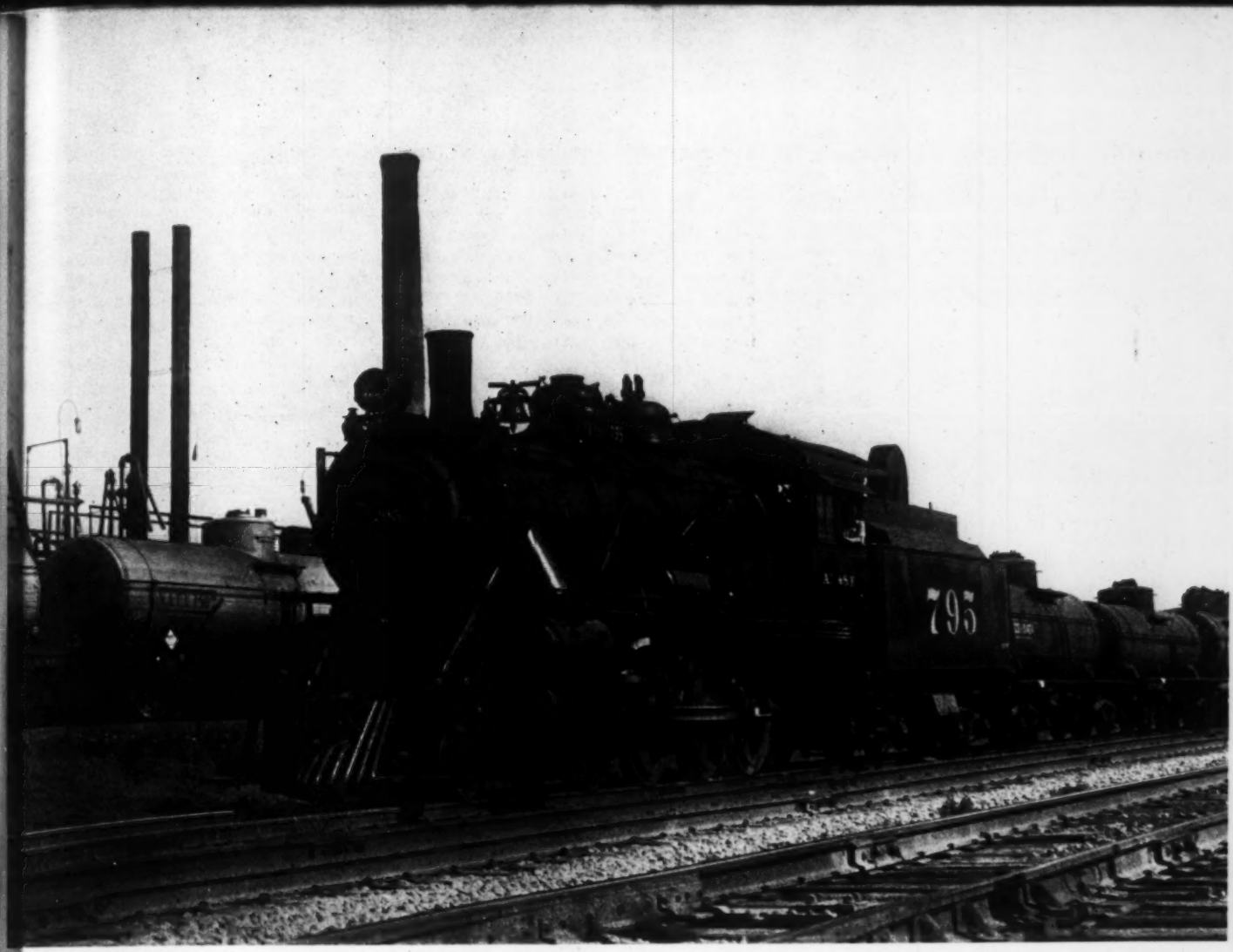
At the beginning of 1941, a critical analysis of the prevailing method of determining fuel allowance indicated that the method of fuel allotment was deficient and that a thorough revision of the method to conform to present-day commercial practice was desirable. The office of the Chief of Engineers authorized a study of fuel consumption at the Army posts throughout the United States. The Army regulations now incorporate the following methods of determining fuel needs based on this fuel consumption study: (1) the degree day method is used for space heating; (2) a constant designated as the pounds of standard fuel per thousand square feet of floor area per degree day is used for determining fuel allotments for various types of buildings. All buildings of the Army are grouped into seven classifications, the fuel allowance varying from 3.5 lb in permanent stone construction to 7 lb in tents. [See the paper Army Fuel Consumption Studies of 1941-42, by L. C. McCabe, S. Konzo, and R. E. Biller, presented at the 49th annual meeting of the ASHVE and published in the ASHVE Journal Section, January, 1943, HPAC.]

The fuel required for water heating, cooking, and laundry purposes is allocated on the per capita basis. The post specifications are annually revised to meet changes in equipment and to insure supply in a restricted market. As manpower shortages and lack of critical materials for machinery have seriously affected coal mine production, coal specifications have been considerably broadened to permit the use of all coals which could possibly be used in the equipment installed in Army posts. Requisitions are forwarded by the Post Engineer each year through the Division Engineer to the Chief of Engineers. The specifications are applied to provide the most economical fuel available. Cross hauling is prevented and all chance of restrictive specifications is avoided. It is the practice of the Chief of Engineers to indicate the requirements in February of each year for all posts, camps and stations to the Quartermaster General, who is purchasing agent for all coal used by the Army. This year the Quartermaster General made this information available to the industries in a formal tabulation considerably prior to the formal advertising for bids. It is anticipated that in the coming year all requirements of the Army will be in storage by the end of October where the nature of the coal and the market conditions permit. Receipt, storage, and delivery of coal on the post will shortly be a responsibility of the Post Engineer.

WHAT SHOULD PLANTS LOOK FOR IN THE WAY OF SCRAP?

Metal shavings; scraps after stamping out parts; broken machinery and parts; cable; old coolant pumps; line shafting; old drills and chucks; rejected pieces; old chain; oil drums; filings and grindings; bolts, nuts and rivets; plungers; pistons; saw blades; old wrenches; pipes and valves; old boilers; discarded equipment of any sort containing iron or steel.

The War Production Board drive for dormant industrial scrap also urges the resale or scrapping of obsolete or unusable machinery, tools, dies and fixtures which are incapable of current or future use in the war production program.—Business Press Industrial Scrap Committee, 3303 Empire State Bldg., New York, N. Y.



FUEL OIL RATIONING

• How Did It Work Out Last Year?

MEMBERS of the American Society of Heating and Ventilating Engineers, functioning through the society's national war service committee and similar committees set up by various local chapters, did an outstanding job the past heating season in assisting local rationing boards on problems involving fuel oil. In many cases, engineers have become regular board members, and in others they have served as consultants to such boards. . . . The editors recently asked some of those who have been particularly active in this work to comment on the present rationing scheme and any suggested improvements for next winter. The first two of the following communications are in answer to this request; they supplement similar contributions which appeared in the April HPAC.

PLAN WORKED REASONABLY WELL; IMPROVEMENT POSSIBLE

WITH THE first heating season under fuel oil rationing drawing to a close, everyone who has been directly concerned with the administration of this war program has learned many lessons. Mistakes were made—both in particular details of the plan itself and in the handling of situations that developed during the winter months—but were inevitable in view of the fact that fuel oil rationing is a pioneering program which had to be developed and administered without the benefit of previous experience or patterns upon which to depend. Despite the inconveniences, burdens, and discomforts which are to a degree an inevitable accompaniment of any rationing program, it must in all fairness be admitted that the plan worked reasonably well. There is little evidence of real hardship or suffering and, most important of all, the objective of cutting overall civilian fuel oil consumption by 25 per cent has been achieved.

Photo courtesy Santa Fe Railway.

Delay Got Program Off to a Bad Start

The program got off to a bad start because of the delay in having available the necessary forms and coupons for providing consumers with their rations. A large part of the difficulty encountered in succeeding weeks, both by the local boards and by the industry, was due to this delay. Every

possible effort should be made to avoid any repetition of this unfortunate situation in handling the issuance of rations for next season.

Training Local Board Personnel

Another difficulty which has been evident from the first to anyone working with the local boards is the very ineffective job of informing and training local board personnel regarding the operational features of the plan. In a program of this type it is essential that instructions and information be promptly available to local boards if they are to do an intelligent job of administration. The delay in the transmission of information from Washington to the local board level during the past season has greatly handicapped the prompt and efficient handling of this rationing program.

Formula Equitable in Majority of Cases

There has been much comment on the complexity of the formula used to determine the rations. Probably no responsible heating engineer would defend the formula as being completely scientific. On the other hand, its application has been fair and equitable in a vast majority of cases. It would obviously be impossible to take into consideration every conceivable technical factor in determining rations for millions of consumers when these rations of necessity must be handled by voluntary boards composed of men and women who, for the most part, have no technical training. A plan which under these conditions provides a maximum of fairness and equity is the best that can be expected, and the present method has achieved this result. Certain types of consumers have been penalized by the application of the present formula, and these inequities should be eliminated in next year's program. The OPA has recognized these situations and is planning to provide for better handling of these groups next year.

The Five Thermal Periods

Another feature of this year's plan which has been severely criticized by the industry is the division of the heating season into five thermal periods. There is no doubt but that this arrangement has cut down the size of deliveries, increased the number of trips, and in general resulted in higher delivery costs for the distributors. Changes and improvements can be made which will preserve the control over fuel oil achieved by the use of thermal periods while at the same time easing the burden imposed on the industry in handling deliveries. While from the viewpoint of the industry in scheduling deliveries thermal periods may be burdensome, the officials of the fuel rationing division in Washington must give first consideration to maintaining control over the critically short supply of fuel oil. The thermal periods not only afford an opportunity to change the unit value of coupons in accordance with the supply situation, but also furnish consumers with a guide for the prorating of their ration over the entire heating season. Both of these factors must be carefully considered in planning for next season.

Policy on Conversion

Great economies in civilian fuel oil consumption have been effected through the conversion of oil burning units to coal. A careful study of the supply situation in all types of fuel should be made before determining the government policy on conversions during the coming months. It may well be desirable to concentrate the drive for conversions in those areas where coal is plentiful and discontinue this effort in those sections of the country where fuel oil stocks are large and transportation situations less acute.

The Office of Price Administration has constantly favored a policy of voluntary conversions in private dwellings and there is no indication that there has been any change of attitude on the part of this agency with relation to this part of the conversion program.

It is obvious to anyone in close contact with the fuel oil picture that rationing is here to stay for the duration. Our task is to work together for the simplification and improvement of the rationing program, so that it will be an effective contribution to the winning of the war.—E. M. MITTENDORFF, consultant, fuel oil rationing division, Office of Price Administration; president, Illinois chapter, ASHVE; engineer, Sarco Co.

THESE CHANGES WOULD BENEFIT PUBLIC AND INDUSTRY

THE FOLLOWING would be what I would suggest—based on the past year's experience—as some of the most desirable changes that could be made in the present fuel oil rationing program. These changes, it is felt, would benefit not only the public but the industry as well.

Rationing has been stated to be at its best a necessary headache—the choice between two evils. If it were not believed necessary and by far the better alternate of two evils, the vast majority of people would not have endured so uncomplainingly what they have this last year.

Formula Generally Satisfactory

Generally, the fuel oil rationing formula used has been surprisingly satisfactory. True, an engineer can show that floor area and fuel oil requirements are not necessarily directly proportional. However, neither would the use of the cubic content or square footage of outside exposed surface (unless used to provide a heat loss calculation, which is impractical due to the work involved) be likely to improve the situation. Floor area certainly has the great merit of being by far the easiest obtainable and usable factor that can be provided by the users of fuel oil without hiring an engineer.

There are changes, however, that could be made that would ease the situation:

Process All Living Area on Same Basis

The processing of all living area showing the same amount of oil used per square foot of occupied floor area should be on the same basis. There seems no legitimate reason for cutting an apartment building used for residential area more or less than a home or duplex flat. Where commercial and residential areas are heated by the same heating system, a division of the floor area with some procedure of processing each division separately would appear more equitable.

It appears the ceiling area for a duplex flat or double home should be the same whether one system is used to heat each family's living quarters or one system used to heat both, which is not the case at the present.

When fuel oil is used in nonconvertible facilities to heat hot water, some added allowance should be provided for younger children. This would be in line with the present recognition in cases where there is a child under four years of age in a family. In the case of hot water, of course, the number of such children would have to be considered.

Changes in Period Coupons

There is an advantage in the use of the period coupons, but unfortunately there are also some unreasonable and unnecessary annoyances resulting from their use. With some slight changes these disadvantages could be reduced greatly if not entirely eliminated. The present type coupon sheets preferably with thirty 1 gal changemakers and up to 100 indefinite (nominal value 10 gal) coupons could be used for applicants having storage tanks of under 275 gal or rations of 1030 gal or less. Coupon sheets having ten 5 gal and ten 10 gal changemakers and 100 indefinite value (nominally 25 gal) coupons could be used for rations up to 2650 gal. Where a ration exceeds 2650 gal some form of ration banking checking account could be provided.

In all three types of ration issuance the five periods could be retained with arrangements that, normally, coupons of two periods would be valid simultaneously—actually three periods during the week of period change. This would allow the present method of control to remain available for use if it ever be needed due to nonavailability of supply; it would allow adjustments to compen-

sate for variation in degree days; it would allow larger deliveries thus saving rubber, etc.; and it would materially reduce the number of coupons to be serially numbered, collected, etc.

Rationing for the year of 1943-44 should start September 1 rather than October 1, which will provide some relief for those hit hardest this last year.

Certainly now that winter's worst is past, storage tanks should be filled both to keep the outside tanks in the ground but in all cases to get the necessary supply in storage early. Naturally, storage in users' tanks should not exceed the 1943-44 ration.

Issue Rations Quickly

The actual rationing program for next year should be gotten under way at once, the procedure to be used established, and the ration in whatever form it is to appear should be issued as quickly as possible.

It would seem practical to use the application already submitted with whatever correction of error originally made on this application as the basis of the issuance of the 1943-44 fuel oil ration. Surely there is not a need to have the public fill out unnecessary forms.

Some clearer understanding of the present and possibly future situation ought to be given to the public, the industry, and the members of the local rationing boards. None of us appears to really understand very clearly whether it is a lack of fuel oil or a lack of transportation.—C. H. RANDOLPH, chairman of a local rationing board; member, Wisconsin chapter, ASHVE; air conditioning engineer, Wisconsin Electric Power Co.

RECENT AMENDMENTS TO FUEL OIL RATIONING ORDER

An index to amendments Nos. 1 to 50 to the fuel oil rationing order appeared on pp. 171-172 of the April HPAC. The following information on amendments Nos. 51-60 has been taken from OPA fuel oil industry letters issued last month:

Amendment 51 exempts the Army and the Navy from the registration and reporting requirements established for dealers and suppliers. At the same time, it provides that whenever any fuel oil is transferred to the Army or Navy within the limitation area from without the limitation area, the agency receiving the fuel oil must forward an acknowlegment of delivery (form OPA R-544) directly to the Washington office.

Amendment 52 sets a new date of "additional facilities" for area "A" (Washington and Oregon). In this area, a ration may be issued for a space heater transferred prior to March 15, 1943, or for a space heater transferred after that date if used to heat the same premises that it heated prior to that date.

Amendment 53 revokes, as of April 1, 1943, the 40 per cent cut in the fuel oil rations of nonpriority commercial, industrial, and governmental consumers. The amendment also provides for the restoration, on application to the local board, of that part of the original ration which can be allocated, on a ratio basis, to the period between April 1, 1943, and the expiration date of the ration.

Amendment 54 provides that a primary supplier may be issued a fuel oil ration record card (in lieu of coupons) to denote the ration allowable for his own consumption. The amendment also establishes a system of accounting for and controlling the use of such cards. No fuel oil ration record card may be used as evidence for purposes of replenishment. The supplier may be given an exchange certificate, or coupons, for any unused portion of his ration as shown by the card.

Amendment 55 advances the validity date of period 5 coupons in thermal zone B of area "A" (Washington and Oregon) to March 29, 1943. Period 5 coupons in this zone are now valid from March 29, 1943, to September 30, 1943, inclusive.

Amendment 56 makes the following changes in the fuel oil rationing regulations:

1) It changes the definition of "fuel oil" by exempting used lubricating oil, whether or not re-refined.

2) It modifies the coupon surrender requirements. Coupon sheets issued as a ration for heat or for both heat and hot water need no longer be surrendered to the board within five days after all the coupons have been detached, but may be retained by the holder until he applies for a ration for the same purpose for the next heating year.

3) It provides that current heat and hot water rations may not be used after their expiration dates. Other current rations, however, may continue to be used for 15 days after the expiration date, providing an application for a new ration has been duly and properly made.

Amendment 57 extends the provisions of amendment 45 to Washington and Oregon, where such provisions did not formerly apply. Persons in area "A" and area "B", who use fuel oil for heat or hot water in residential premises, may now apply for supplementary "hardship" rations, as provided in section 1394.5310 of ration order No. 11.

Amendment 58 contains the following provisions: (1) A person whose *coupon sheet* is lost, stolen, destroyed, mutilated or wrongfully withheld may apply for a replacement in the manner provided by procedural regulation 12. All applications for replacement coupon sheets made on or before March 28, 1943, shall be governed by the former procedures. (2) A person whose *delivery receipt*, form 1125, is lost, destroyed, or multilated may apply to the issuing board for replacement. The application shall be made in writing, under oath or affirmation, and shall contain the following: (a) The name and address of the applicant. (b) The date and place of issuance, and if possible the expiration date and serial number of the receipt. (c) A description of the premises, vehicle, boat, equipment, or process for which the receipt was issued. (d) A statement of the amount of fuel oil acquired in exchange for receipts (if any) which were issued together with the lost, destroyed or mutilated receipts. (e) A description of the manner and circumstances of the loss, destruction, or mutilation. (3) If the local board is satisfied that the *delivery receipt* has been lost, destroyed, or so damaged or mutilated to be unfit for use, it may, at its discretion, issue a replacement delivery receipt limited to the gallonage value of the unused receipt. It shall enter on the issued delivery receipt, the expiration date that appeared on the replaced delivery receipt.

No person receiving a replacement delivery receipt shall use, attempt to use, or permit the use of the original receipt. Damaged and mutilated receipts shall be surrendered to the board.

Amendment 59 provides that the regional administrators for regions VII and VIII may extend the dealer and supplier "bail out" dates for all or any part of area A (states of Washington and Oregon) within their respective regions. The dates for dealer "bail-out" shall be fixed not later than May 1, 1943, and for other industry levels not later than May 15, 1943.

Amendment 60 contains the following provisions: (1) A ration application for domestic cooking for canning and/or preserving (6 months' period) shall be made on form 1103 or 1103A. The applicant shall supply the information required by the form and shall state in addition the number of hours the oil or kerosene burning equipment will be used and the amount of fuel oil needed for the canning and/or preserving.

Get Your Scrap in the Fight!

Salvage for Victory

OPA ANNOUNCES FEATURES OF FUEL OIL RATIONING PROGRAM FOR NEXT YEAR

The fuel rationing division of the Office of Price Administration announced on April 24 highlights of the program for next year, as follows:

Early in 1943 the staff of the OPA fuel rationing division began an intensive analysis of the current fuel oil program, for the purpose of improving the plan for next year. A primary consideration was to determine the advisability of discarding the present coupon plan in favor of some alternative method. The proposed alternative methods included various certificate plans, check book plans and degree day plans. It was the consensus, however, that an improved and streamlined coupon plan would be preferable to any of the proposed alternatives. The re-education of the public and the industry and the training of the local boards appeared to be a great handicap in adopting any alternative plan. The desirability of providing for summer deliveries, which would be impossible due to time limitation, further discouraged the adoption of another type of rationing plan.

In outlining the most important features of the new program, we must state that some of the points outlined are not completely "frozen," but indicate the latest thinking and will probably be adopted.

1) Reregistration before June 15—with rations to be issued in June and early July.

a) Most rations to be reissued on this year's basis, after review of the calculations.

b) Rations for small homes to be adjusted upward.

c) Upward adjustment of rations for all homes in certain subzones in zone D.

d) Area ceiling to be raised for all zones from 2000 sq ft to 3000 sq ft for the first person, with the 600 sq ft allowance for the second person and 300 sq ft for each additional person.

e) Nonheating consumers will not reregister in June, but will continue on present schedules.

2) The five thermal periods will be continued on the same basis as this year.

a) Ration divided into six parts—the sixth part to be fixed value inventory coupons.

b) Inventory coupons to be good the entire year.

c) In PAW district 2 only, coupons for period 3 will be made valid at the same time as period 2 coupons; likewise period 5 coupons will be valid at the beginning of period 4.

d) For periods 1, 2 and 3 the dates in all zones will be identical. Periods 4 and 5 will have the same dates in zones A, B and C, with a variation in only zone D.

3) Coupon validity extended for larger deliveries.

a) Period 1 coupons plus the inventory coupons are valid starting July 1.

b) Overlap of coupons' validity for one full period. Thus coupons for any period are valid during entire succeeding period.

4) Coupons and coupon sheets are greatly improved.

a) New class 4, 5 and 6 coupon sheets will replace the present class 1 and 2 sheets in the new program.

b) Coupons will have better perforations.

c) Delivery record to be eliminated, thus reducing the amount of written material on the coupon sheet stub.

d) Larger type and much clearer distinction between periods and coupon values.

e) Smaller coupon sheets.

f) Class 4 sheet will have 66 one-unit (10 gal par) coupons, plus change coupons, totaling 800 gal at par. The class 4 sheet will be used for consumers with a ration larger than 300 gal but with a storage capacity too small to permit use of 50 gal coupons described next (class 5 sheet).

g) Class 5 sheet will consist of 36 five-unit coupons (par value 50 gal) plus 36 change coupons. Class 5 sheets will be used for rations from 300 to 4000 gal where storage capacity permits use of the five-unit coupon.

h) Class 6 sheet will be used for rations of from 4000 to 20,000 gal. The sheet will have 36 coupons of 25 units (250 gal par) plus 36 change coupons, totaling 10,000 gal per sheet at par value.

i) In accordance with above, no consumer should have more than two sheets of coupons.

j) Definite value coupons will be issued for rations up to 300 gal (instead of 200 gal as at present).

5) Requirement of writing the serial numbers on the coupons will be eliminated.

6) Ration banking for consumers.

a) All consumers, both heating and non-heating, with an annual ration of 20,000 gal, will participate in ration banking. Instead of coupons they will receive a certificate to be deposited, and then draw checks for all deliveries.

7) Ration banking for suppliers and dealers.

a) All primary suppliers and secondary suppliers will participate in ration banking.

b) Dealers above a certain gallonage level will come under ration banking. The minimum gallonage requirement for participation is now being determined, based on the acceptable number of accounts.

8) Ration banking for consumers, suppliers and dealers will start July 1.

a) Deposit slips, checks, and other material will be supplied by the banks and the Office of Price Administration, with no cost to the depositor.

9) The delivery receipt will be eliminated. Under the ration banking plan, the need for the delivery receipt (form R-1125) will be eliminated. Ration banking consumers (above the 20,000 gal level) will receive a certificate from the local board to be deposited at the bank.

10) There will be an improvement in the thermal zone arrangement. The greater number of zones will permit much greater flexibility in adjusting for changes in the available supply and the weather.

a) The present zones, A, B, and C will be divided vertically at the north-south dividing line between PAW districts 1 and 2.

b) The 17 eastern states will therefore be classified as zones A-1, B-1, C-1, and D, and the states within PAW district 2 will be listed as A-2, B-2 and C-2.

c) The three zones of Washington, Oregon, and Idaho will be designated as zones A-3, B-3, and C-3.

d) Zone D, lying entirely within PAW district 1, will remain as a single zone.

11) The conversion policy for the next heating season is not yet determined. Among the possible modifications for next season is a recognition of a lesser need for conversions in some areas than in other areas. The entire conversion policy is now being intensively studied, with particular consideration of the availability of the alternate fuels.

12) A reregistration of suppliers and dealers will not be required in making a transition to next season's program. The extended period of industry "bail-out" has presumably straightened out practically all suppliers and dealers so that their books should now be in shape for a spot audit. If the need for a general reregistration should develop, it can be made at a later date.

13) The Office of Price Administration plans to have a greatly improved public relations program to start in May. Further training of the local boards is also planned.

SAM LEWIS' PAGE

By Samuel R. Lewis
Consulting Mechanical Engineer
Member of HPAC's Board of Consulting & Contributing Editors

★

SHOT GUNS AND SAFETY VALVES

WE ARE all familiar with steam safety valves and water relief valves. They serve vital purposes and generally save from damage the equipment which they are intended to protect, as well as safeguarding the lives of the public. These devices also are used for protecting pressure vessels holding refrigerants and the technical lore concerning them is surprisingly complex.

The valve can have a mechanism which will open at any reasonable adjusted pressure, but when the pressure has been reduced the problem is to make the valve close perfectly tight after reducing the pressure to the predetermined extent. If a pop safety valve is too small, it may not permit release at a rate sufficiently in excess of the pressure increase within the vessel. If the pop safety valve is too large, the sudden reduction in pressure may subject the vessel to objectionable explosion-like shock.

I saw recently three large pop safety valves on a single boiler. They were connected out-of-doors horizontally about 20 ft through a wall, then the pipes, open on top, were run up several feet. In cold weather a trifling leak at the valve thus piped up, would be unnoticed. The steam easily could condense in the long discharge pipe and could freeze and plug off entirely the escape pipe.

A boy carrying a shot gun when hunting rabbits carelessly permitted the muzzle to fill with snow which melted and then froze. The next time he pulled the trigger against a distant rabbit he blew off about six inches of the end of the barrel, fortunately living, unharmed, to carry home the gun. He didn't carry home the rabbit.

All safety valve discharge pipes should be kept inside where they cannot freeze, at least as far as the bottoms of the vertical risers which may extend out-of-doors if necessary, and the tops of such risers should have return bends or equivalent protective covers to reduce the danger of their becoming clogged.

WARM AIR FURNACE SAFETY VALVES

The war pressure to reduce the application of critical materials, especially in "offense" living quarters, has forced the requirement that most of the 1943 housing projects for war production plants shall be heated by forced circulation warm air furnaces, burning coal, and manually fired.

In many cases the ducts leading into the buildings from the furnaces are made of nonmetallic materials; and in all cases the buildings are of temporary construction and decidedly are not even fire resisting. In many cases the Washington-developed drawings and specifications go to engineers and architects and contractors educated in steam and hot water and by no means experienced in handling high temperature air.

As long as supply of heat to a boiler is balanced with condensation of steam in a heating system the safety valve required by law merely acts as a sleeping watch dog. If, however, the steam is not condensed and the fire is not checked, the safety valve does business.

With a warm air furnace in these housing projects the heat removal from the furnace depends upon operation of an electric driven fan, and the heat input generally depends on some neighboring ex-farm hand who shovels in coal without benefit of any pressure gage and usually without any thermometer and without any knowledge of temperature conditions in the remote rooms which he serves. As long as the fan runs there may be no trouble, but fuses blow, bearings do run dry, and fans do stop occasionally when the furnace is piled high with red hot coal.

Usually there is no provision by the steam-educated designers and contractors for anything like a "safety valve" on such jobs. There is no supervision by boiler inspectors or boiler insurance authorities. If the fan stops, the temperature in or even some distance away from the furnace bonnet may easily reach the ignition temperature of wood, and as the furnaces rarely are in fireproof basements but generally are on the same level as the heated spaces, circulation of cooling air ceases. I have seen the steel domes of such furnaces fallen in and melted through by heavily loaded banked fires when deprived of adequate air cooling.

In one housing project inspected recently, the supply of cooling air did fail four times in a single large furnace plant, due to fan motor failure, and the building construction was ignited and burned seriously. Fortunately there was no loss of life induced by the fires.

Safety valves to serve such installations had to be devised. They consist of escape pipes leading out-of-doors through fireproof construction and provided with insulated dampers which drop open of their own weight when released by the melting of fusible links. Telltale indicators hope to tell the firemen that the dampers are open so that he will have to replace the links before resuming operation.

It remains to be seen whether in the many poorly designed and installed warm air heating systems for temporary housing projects all over the country, there will be freedom from serious fires. Oldtimers in the warm air heating industry for large public buildings knew about the necessity for safety valves, but most of the oldtimers unfortunately are dead and have no voice in present design.

An old Ohio state law stipulates that there shall be no direct door between a school house furnace fire room and the suction side of the fan which serves the furnace. This was based on the well proved fact that when the door was opened the fan pulled smoke and gas out of the fire door and delivered it to the rooms of the building. Few of the present large scale warm air heating system designers know about that well founded law. Ohio had a disastrous school fire that made the industrial commission danger conscious.

OIL RATIONING

When the war — and the rebound after the war — have become only memories, the end of the pleasures of advising fuel oil rationing boards may be regretted.

Acting as an adviser has an occasional lighter vein—for example, being called at midnight to certify to an emergency auxiliary ration to keep the water pipes in the home of the head of the rationing board from freezing.

Apparently—and this is of course a kindly and human trait—the family doctor takes pleasure in signing an endorsement for extra fuel because of illness. One doctor, certifying in terms of heart-rending pathos the need of auxiliary oil for two old friends, did inadvertently transpose the description of their ailments and their respective sexes with amusing and somewhat embarrassing results.

TESTING TOXIC ATMOSPHERES

Electrostatic precipitators are used in the evaluation of various industrial dusts

N. R. Bernz Explains the Methods of Determining the Impurities in Industrial Air, a First Step in a Program for Industrial Health Conservation

SUMMARY—In a recent discussion at a meeting of the National Safety Council, Mr. Bernz gave a brief description of some of the more commonly encountered toxic substances in war industries, and methods for their evaluation. This material on dusts has been taken from his paper; in future issues will be presented the sections on gases, metal fumes and vapors, solvent vapors, and acids.... Unless properly controlled, exposure to these materials may result in ill health among industrial workers with accompanying absenteeism and interference with war production. The control of these industrial poisons should, therefore, be an integral part of an extensive program of industrial health conservation. Such a program is of prime importance at a time when every piece of manufactured goods plays an important part in winning the war, and is of interest to ventilation engineers because ventilation is the principal method of control.... Mr. Bernz, consulting engineer, is a member of HPAC's board of consulting & contributing editors

FOR HALF a century or more the United States has been looked upon by the rest of the world as an industrial giant, a nation in which industrial production has surpassed every other line of endeavor. At no time, however, has the productive capacity of this country meant more to us and to the rest of the world than it does today.

We can afford no interference to operations of our industrial plants. Prevention of accidents and occupational disease becomes our duty. As an industrial hygienist, I may perhaps render some service by reviewing outstanding occupational disease hazards in war industries.

Dusts

Silica-bearing inorganic dusts are found in many industries. For example, mining of iron ore in the steel industry presents exposures to free silica dust in considerable quantities. Buffing, polishing, and grinding operations in a great many industries generate inorganic dusts, which for the most part consist of aluminum oxide and silicon carbide, but also include free silica in amorphous and crystalline forms.

For the purpose of quantitative determination, dusts may be divided roughly into three classes:

1) The inorganic type, such as free silica and asbestos, which is collected and the number of particles per unit volume of air determined microscopically.

2) Organic dusts of natural origin, the amount of which is usually determined by weight. Typical of these are tobacco and flour dusts.

3) Synthetically manufactured organic compounds which may occur in the form of dusts, such as TNT and ammonium picrate. These substances when present as air contaminants in low concentrations are generally evaluated quantitatively by chemical means.

Besides above types, there are also metallic dusts such as lead, zinc, cadmium, manganese, etc.

Inorganic Dusts

The most common method for evaluation of this type of dust is to collect air samples in liquid solutions by means of an impinger (1),* and to make the quantitative determination microscopically. When calculating the dust concentration, usually expressed in number of particles per cubic foot of air, the microscopic calibration factor, the volume of the sampling liquid, and the size of the air sample are taken into consideration.

The sampling procedure, microscopic arrangement, and calculations are extremely simple, but the actual

*Numbers in parentheses refer to the bibliography.

counting is a tedious job associated with severe eye strain and requires considerable experience before dust counts can be relied upon. In recent years the microprojection method (2) has been used for counting of impinger samples. With this method, in which the microscopic field is projected on a translucent screen, the eye strain experienced in direct microscopic work is eliminated.

Other methods for evaluation of this type of dust are by means of electrostatic precipitators, (3) and various types of "grab" samplers. With the electrostatic precipitator, the dust is collected in a dry state and is either weighed as is or suspended in water and counted in a manner similar to that employed with the impinger method. Several of the grab samplers have microscopes incorporated with the sampling device and these are calibrated in such a manner that the number of particles per cubic foot of air can readily be obtained by almost instantaneous readings. (4)

Organic Dusts (of Natural Origin)

This group as a rule is not classified by medical authorities as fibrosis producing dusts, and hardly warrants discussion here. While claims do exist to the effect that some dusts in this class have produced respiratory irritation,, bronchitis, asthma, etc., these dusts are generally looked upon as nuisances rather than occupational disease producers. No official physiological threshold limits have, therefore, been established and sampling of this type of dust for the purpose of evaluating an occupational disease hazard has little or no meaning.

Most of these dusts, however, are explosive when dispersed in certain proportions in the air and require control from this point of view. Considerable work to establish explosive limits for this type of dust has been done by the United States Department of Agriculture.

Organic Dusts, (Synthetic)

Trinitrotoluene and ammonium picrate will be discussed under this heading. In the manufacture of TNT and ammonium picrate, both of which represent basic war industries, we are confronted with toxic raw materials as well as hygienically injurious final products. Great quantities of toluene, anhydrous ammonia, sulfuric and nitric acids are used, all of which are classified as industrial poisons. TNT and ammonium picrate are themselves systemic poisons as well as skin irritants known to have produced fatalities and severe cases of dermatitis.

A method for sampling and determination of TNT was described recently by Pinto and Fahy. (5) This procedure calls for the use of 10 cc of isopropyl alcohol in the midget impinger. The chemical determination is based on the reduction of TNT to triaminotoluene, and finally, a colorimetric comparison with known standards.

Ammonium picrate is highly soluble in water, which therefore can be used as the collection medium in an impinger when sampling for this material in industrial atmospheres. The deep color which results upon solution of ammonium picrate in water is also evident in extremely low concentrations and for this reason a direct colorimetric comparison of the sample with known standards can be made. With this method there is a possibility of interference from dinitrophenol, the extent of which has not been determined (6).

Bibliography

1) Greenburg, L., and Smith, G. W. A New Instrument for Sampling Aerial Dust. R.I. 2392, U. S. Bureau of Mines, 1922.

2) Brown, Carlton E.; Baum, Lester A. H.; Yant, William P., and Schrenk, Helmuth, H. Microprojection Method for Counting Impinger Dust Samples. R.I. 3373, U. S. Bureau of Mines, January, 1938.

3) Barnes, E. C., and Penney, G. W. An Electrostatic Dust Weight Sampler. Jo. Industrial Hygiene & Toxicology, 20, 3, p. 259, March, 1938.

4) Bernz, N. R. Dust Counts and Their Significance. Heating, Piping & Air Conditioning, March, June and October, 1942.

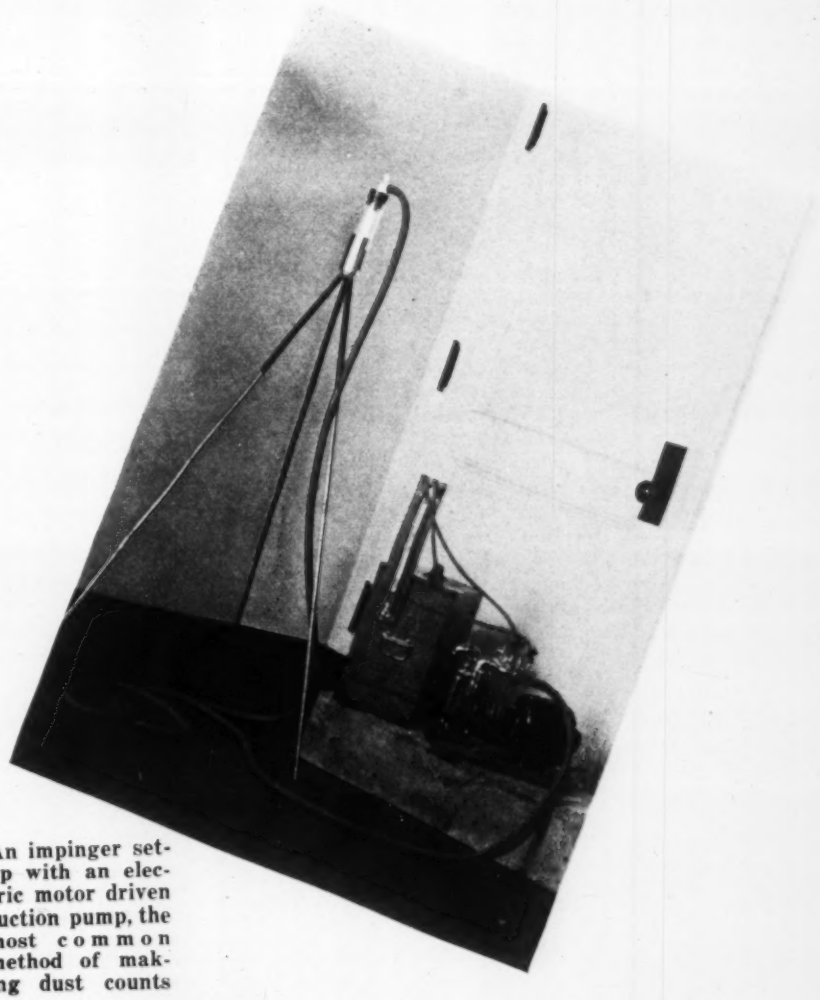
5) Pinto, S. Sherman and Fahy, John P. A New Colorimetric Method for the Determination of T.N.T. (2, 4, 6 Trinitrotoluene) in Air. Jo. Industrial Hygiene & Toxicology, 24, 2, p. 24, February, 1942.

6) Sands, Frederick W., 189 Claremont Avenue, New York, N. Y. Unpublished data obtained through personal communication, August, 1942.

WPB RELEASES SMALL FANS

Small sizes of centrifugal type air boosters or underfire coal burning fans used in connection with furnaces and in the hands of dealers were released for distribution by the War Production Board in an amended general limitation order L-280. Specifically, the amended order releases for installation in connection with new or existing heating furnaces all new air boosters or fans in inventories of dealers that have a capacity of 2500 cfm and less with motors of ¼ hp and less.

These items originally were frozen for use in war housing projects. They were released because they are too small to be installed with the heating units in the housing projects now planned or under construction.



An impinger setup with an electric motor driven suction pump, the most common method of making dust counts

Air Recovery by Gas Adsorption Cuts Equipment Weight and Costs

Activated Carbon Units Allow Increased Air Recirculation and Reduce Outside Air Heating and Conditioning for War Production

An assembled air recovery unit, showing the activated carbon canisters

SUMMARY—It costs money to heat the outside air required for ventilation in winter, and to cool and dehumidify it in summer; important, too, in wartime is the extra heating and refrigerating equipment which must be installed for this purpose. In the new plant described here, outside air requirements were drastically cut by passing the recirculated air through gas adsorbing activated carbon—in effect, a "giant gas mask" for the entire plant . . . The data contained in this article were obtained from the W. B. Connor Engineering Corp.

IN PROVIDING for air conditioning at a new Pratt & Whitney plant of United Aircraft, the principle of "air recovery," for adsorbing gaseous impurities from air and thereby making it suitable for re-use, has been introduced and is credited with drastic savings both in the initial installation of equipment and in operation. The designers were Albert Kahn Associated Architects and Engineers, Inc. The plant was erected by Long Construction Co. and Turner Construction Co.

It was determined that part of the plant was to be equipped with "temperature control" units. The areas are served by a total of 39 separate systems. A plan and perspective of the fan room of one of these systems is shown herewith; it illustrates the arrangement and relation of the equipment, and the air flow and functioning of the control dampers. While the size of the several systems varies, the operation and function illustrated are typical.

It was determined that the requisite ventilation for the cafeteria, locker rooms, toilets, and similar areas ordinarily demanding a high air change rate would be 458,000 cfm. Due to design conditions, over half of this air replacement would have to be drawn from summer cooled as well as winter heated areas, while the remainder would be obtained from winter heated areas only.

Through the application of activated carbon air recovery, it was found possible to reduce the outside air to 77,000 cfm, more than ample for adequate oxygen make-up for these areas, by qualifying the difference (381,000 cfm) for re-use and adding it to recirculation. Thus the required ventilation and total air circulation is fully maintained, but the outside air volume is reduced by 80 per cent.

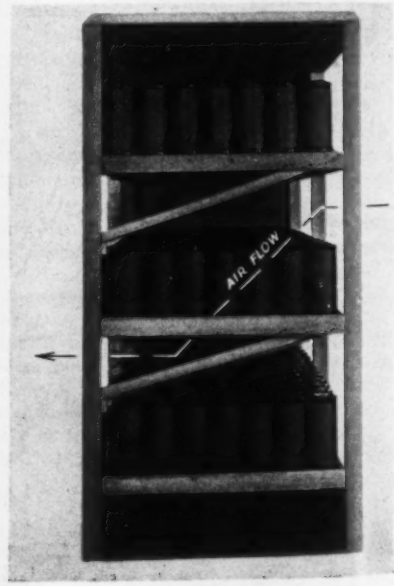
Since the chief purpose of the air recovery installation is to reduce the outside air conditioning load, it is only necessary that it be in operation during periods when the outside temperature rises or falls below certain limits. By designing the method of control accordingly, full advantage can be taken of outside air ventilation when it imposes little or no demand on cooling or heating energy. This is shown graphically in the flow diagram.

When little or no conditioning of outside air is required the outside air and exhaust dampers are full open and the system operates as straight ventilation. When the outside temperature is such that heating or cooling is demanded, these dampers close to 20 per cent of capacity and the recirculating damper on the air exit side of the air recovery unit opens to mix decontaminated return air with the reduced outside air volume. It will be noted that the total volume of uncontaminated supply air is maintained regardless of whether such air is obtained from outside or recovered from the conditioned zones. Also, that the life of the carbon is conserved or extended by limiting its operation to the periods when conditioning is demanded.

Savings in Initial Installation

Conservation of critical materials was a major objective of the designers. Through the application of air recovery, the re-use of 381,000 cfm

A sectional view of one of the air recovery units, with side removed



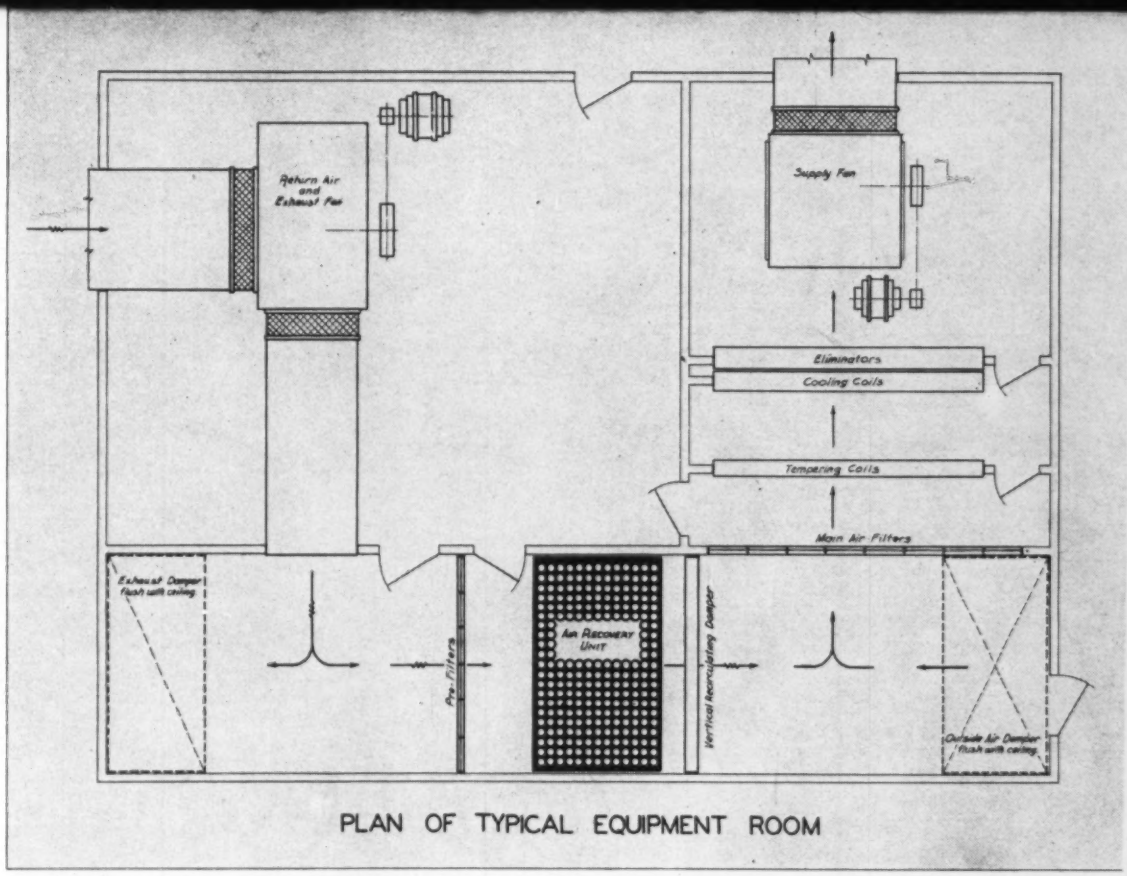
of conditioned air saved approximately 800 tons of refrigeration equipment and 33,000,000 Btu per hr capacity of heating apparatus. Air recovery permitted the important tonnage of metal required for the necessary equipment to be diverted to other essential war purposes.

Savings in Operation

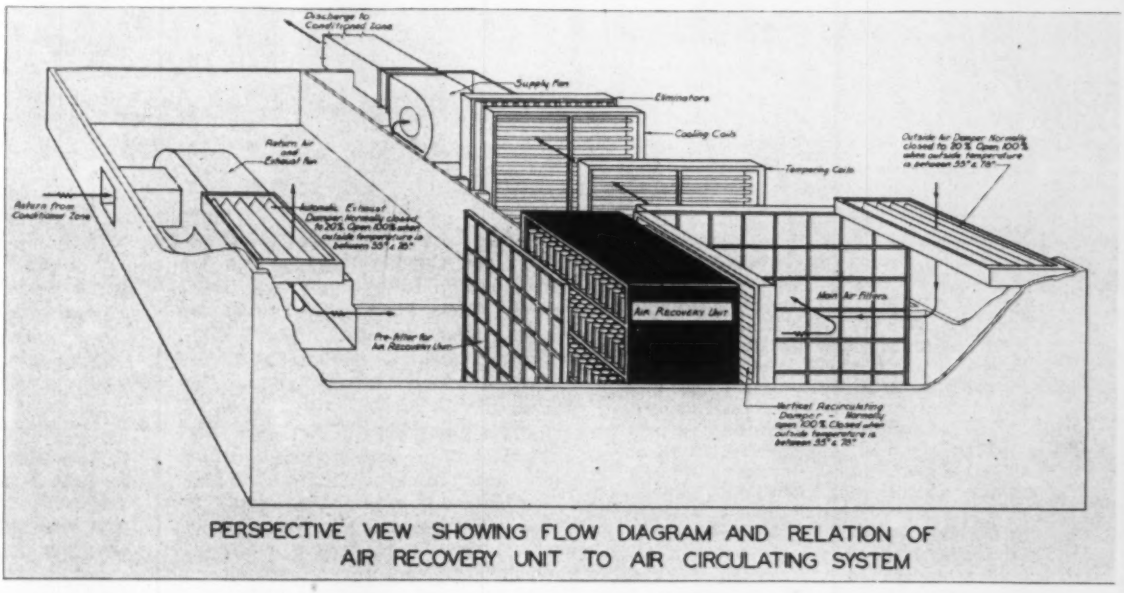
The operating saving is estimated at over 53,000,000 lb of steam per heating season. Converted to oil with 75 per cent overall heating efficiency, this represents a saving of approximately 500,000 gal of fuel oil per heating season.

The saving in summer cooling operation on the basis of 60 per cent average load and only 1500 operating hours at ¾ hp per ton will equal 450,000 kwhr per cooling season. However, the refrigeration compressors are to be steam turbine driven, and therefore this saving will likewise be realized in fuel economy rather than electric energy.

The above conservation of primary equipment and operating energy is based upon design conditions for this plant location, which are: Winter design, minus 10 F; winter average, October 1 to May 1, 44.3 F; summer design, 100 F dry bulb, 76 F wet bulb; average load, 60 per cent.



PLAN OF TYPICAL EQUIPMENT ROOM



PERSPECTIVE VIEW SHOWING FLOW DIAGRAM AND RELATION OF AIR RECOVERY UNIT TO AIR CIRCULATING SYSTEM

In the above view, the automatic exhaust damper at the left is normally closed to 20 per cent. It is open 100 per cent when the outside temperature is between 55 and 78 F. The vertical recirculating damper in the center is normally open 100 per cent. It is closed when the outside temperature is between 55 and 78 F. The outside air damper at the right is normally closed to 20 per cent. It is open 100 per cent when the outside temperature is between 55 and 78 F.

"Giant Gas Mask"

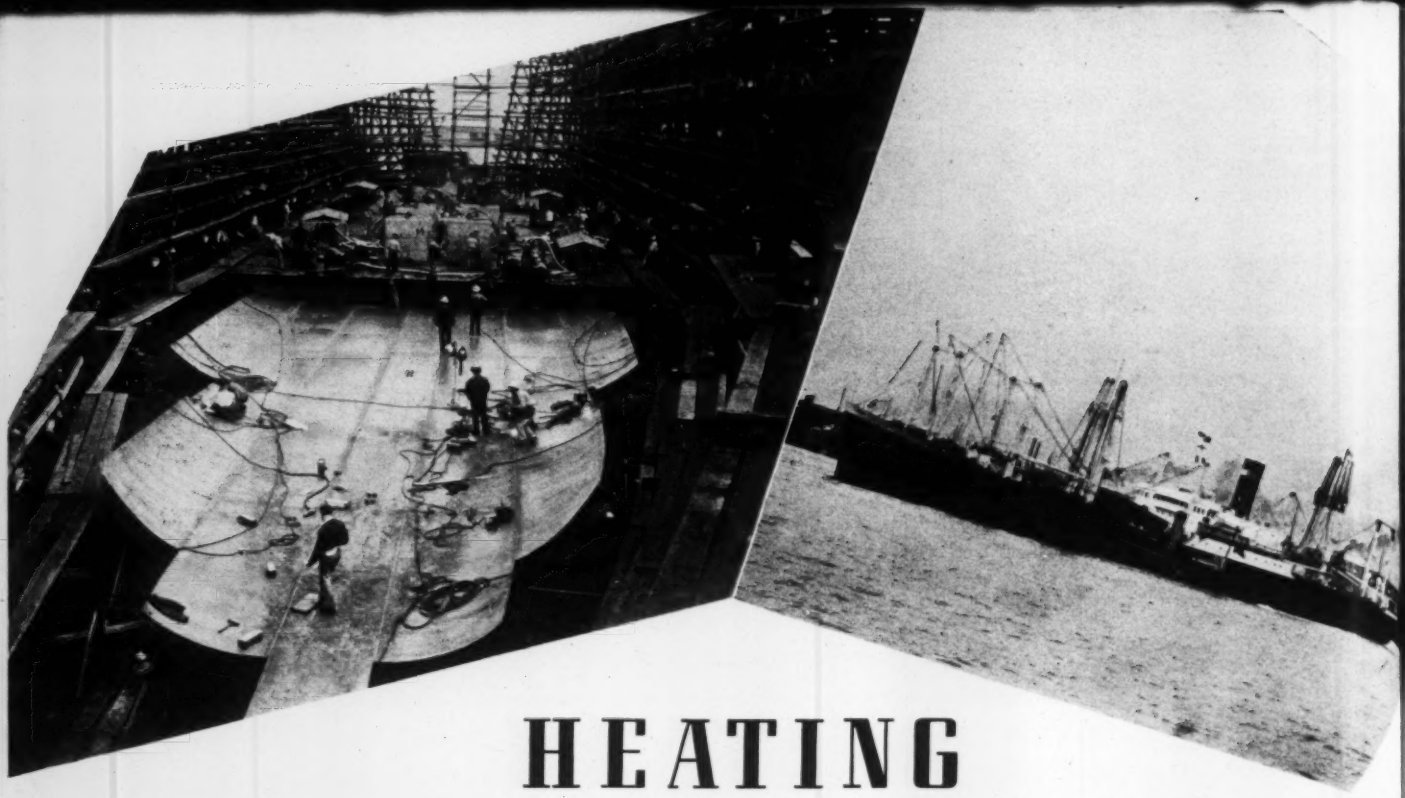
The photographs show a standard canister assembly of the air recovery equipment similar to the 39 furnished for this project. A recent feature article in Fortune refers to this apparatus as "in effect a giant gas mask, using the same plentiful filter substance—activated carbon—that was developed for World War I gas masks." The perforated carbon filled canisters used in the air recovery system are light in weight and readily removable. They are mounted in multiple on one or more supporting manifold plates in such manner that all air to be treated will pass uniformly through the granular carbon.

The assembly is flexible to suit space conditions. The resistance to air flow is 0.15 in. water gage. The carbon will maintain its efficiency for from six months to two years, depending upon the concentration of contamination. Upon exhaustion, the carbon is reactivated for re-use.

The air recovery equipment is nonmetallic and noncritical. When the late Albert Kahn, highly conservation minded, looked into this aspect of the equipment, he found that it had been converted to noncritical structure some six months prior to the development of acute metal shortages. Moreover, this new construction is said to be actually superior to the former metallic design.

Installations, similar to that in the Pratt & Whitney plant, have been specified for a number of other war plants, many of which are already in operation.

George W. Meek, WPB conservation specialist, in his widely discussed article, Your Place in the Smart Man's War, which appeared in HPAC last August, discussed conservation in air conditioning at considerable length and indicated the value of odor adsorbing equipment in the reduction of the amount of outside air necessary for satisfactory air conditioning.



HEATING THE SHIPS FOR VICTORY

Hot Water Heating for Marine Use Discussed by John Clarke

SUMMARY—Cargo ship construction is one of the vital elements of our national war effort. To meet the demands of victory, all-out ship production is required, and many engineers, contractors, and suppliers are now engaged in marine design and construction whose previous experience has been largely with land installations. . . . Mr. Clarke—head of the heating, ventilating, and refrigeration unit of the engineering plan approval section, Great Lakes regional office of the U.S. Maritime Commission—explained in the March HPAC the requirements of marine heating installations, design temperatures and heating calculations, ship heating services and control, and gave information on proper submittal of plans for government work. In April, he covered design and installation of the heating system piping and equipment design. He concludes this month with information on hot water heating systems and insulation. . . . His material pertains primarily to cargo ships, and where Navy or Army work is concerned the designer should be particularly careful to familiarize himself with the special standards and requirements of the armed services

WHERE SMALL ships are concerned, a hot water heating system often has very distinct advantages over steam systems in simplicity and ease of operation. For this reason, there is an extensive number of hot water installations being made in small boats at this time.

A hot water installation is advantageous in that it can be adapted more readily to summer conditions when domestic water requirements are the sole need for heat. In addition, the water temperature may be varied either manually or by an outside thermostat to minimize the probability of overheating in mild weather. This type of system would be much more desirable on any ship or boat where the only alternative would be a low pressure steam system operating with gravity returns to a heating boiler. Zoned ventilation heating systems heated with hot water have also been proposed for heating fair sized passenger-cargo ships. One such system, for which the designer applied for patents, was to be installed on a group of passenger and cargo ships prior to the war. It was the engineer's idea to zone the ship for heating, as for the ventilation systems, preheat the air in the usual manner, and then provide the final heat requirements by means of hot water air heaters in each stateroom. Each heater was to be provided with modulating control valves and room type thermostats. The hot water was to be heated by zone converters and the water circulated on a one pipe loop. It was estimated that this system could be installed for about the same cost and weight as a split system designed with convectors and preheated ventilation air.

In considering a hot water system for ship or small boat use, keep in mind that a forced circulation, one pipe system should always be used unless special conditions exist which do not permit this. Of course, a one pipe system would not be suitable for combined comfort cooling and heating installations because of the high friction in this type of room cooling unit. And as for shore design, where air heaters and unit heaters of high friction exist (compared to the convectors or other heating units), these units should be put on their own individual reversed return, two pipe system and not on the one pipe loop.

Design Suggestions

Regarding the installation of one pipe heating systems on shipboard, the following should be considered:

1) Use two (or more, if necessary) water loops. By providing one loop port and one starboard, a more symmetrical design will be obtained. Thus it is possible that fewer radiator sizes will be needed, since the corrections for drop in water temperature will also be symmetrical. More important, the use of two loops will also decrease the size and weight of the pipe in most cases.

2) The use of a high temperature drop (boiler outlet to boiler inlet) increases the size of the heating units required and decreases the pipe size.

Conversely a low drop decreases the size of the heating units and increases the piping size. All things considered, it is recommended that a 20 F temperature drop be used for ship design.

3) The use of high temperature water will go a long way in the direction of decreasing pipe and heating unit sizes. In no case should the water temperature be less than 200 F (average temperature) and it is believed that 240 F would be far more desirable.

4) In picking the pump, base the head on maintaining the highest piping velocities practicable. This will keep the pipe sizes to the minimum. The increase in pump horsepower under such circumstances will be of no real consequence. It is suggested that the main and branch loop main velocities be kept as close to 5 fps as possible. Branch velocities should be somewhat lower (3 fps) and would depend upon the friction in the flow fitting, and the friction in the radiator loop itself.

Controlling Hot Water System

In controlling a hot water heating system, an aquastat should be provided for the boiler as usual. The circulating pump should be operated (on and off) manually. In no case should a room thermostat be provided for this purpose, because there is no place that such a thermostat can be located where it will measure the ship's average heating requirements.

A very desirable refinement of control is to provide an outside thermostat which will vary the water temperature in proportion to the heat requirements. Such a thermostat will help to prevent overheating in the quarters when the radiators have been left on.

Vents

For marine design, the use of automatic air vent valves should be avoided. Unit heaters, domestic water heaters, convector radiators, etc., should be provided with an air chamber and key operated valves. The piping systems should also be provided with an air chamber of appropriate size, if necessary.

The expansion tanks should be kept to the practicable minimum. It is suggested that they be not larger than 10 per cent of the volume of the system (including the piping and boiler).

Electric Heating

With very few exceptions there is no place for electric heating on merchant ships. It has often been proposed, and for some applications it has been used. But in any case, electric heating should be used only for isolated spaces requiring a small amount of heat, where it would be impracticable to run heating piping.

It should be kept in mind that electrical heat costs about five times as much as steam heat in fuel alone. In addition, the initial and installation cost of electrical cable is definitely higher than the comparable cost of piping. Over and above this, it is very important to keep constant generator loads, and thus the generator sizes, to the minimum.

Ship and Piping Insulation

The insulation for living spaces in ships usually consists of standard commercial insulation of the various noninflammable types, such as rock wool, glass wool, sprayed asbestos, etc., in 1 or 2 in. thickness and covered with ¾ to ⅞ in. thick marine sheathing (over stiffeners and beams). Such insulated spaces are distinct improvement over the uninsulated spaces formerly common on ships. The present heat coefficient U of 0.10 to 0.20 represents a material saving in heat over the uninsulated spaces where U equaled about 1.3 for bare steel.

The insulation is provided on all exposed surfaces in the living spaces except that it is not permitted in toilet, washroom, and shower spaces. In these spaces, cork paint only is provided. Except where covered by the sheathing, all beams and stiffeners should be covered with insulation on a particularly good job. However, this is seldom done.

The heating piping insulation is of standard thickness, 85 per cent magnesia, except that because of war requirements some substitutions are being permitted.

In all of the above insulation, and for insulation on shipboard in general, the use of inflammable insulation is not permitted. Also, the use of insulating materials which smolder and give off noxious fumes is discouraged and should be avoided if possible.

[Photos courtesy U. S. Maritime Commission and Oregon Shipbuilding Corp. (construction view).]

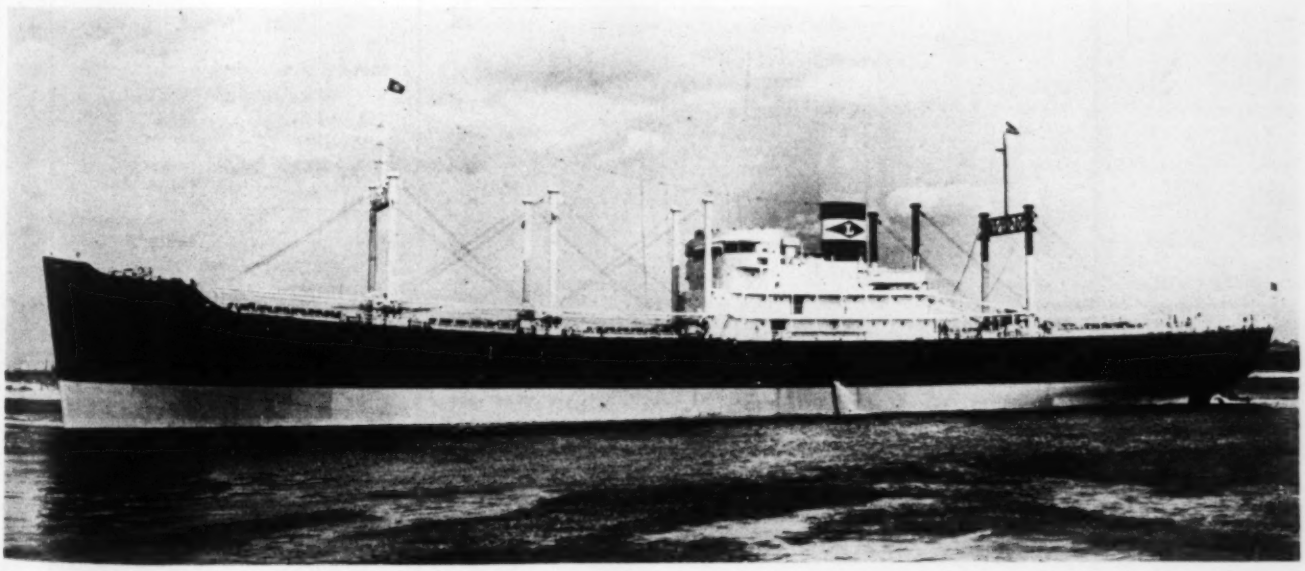
ASSURES MAINTENANCE OF PORTABLE FANS

Users of portable electric fans are assured of the maintenance of such equipment, insofar as service depends upon the supply of repair and replacement parts, through provisions of general limitation order No. L-176 (domestic and commercial electric fans) as amended by the WPB last month. Manufacturing of certain repair and replacement parts on a limited basis is provided for in the revised order, easing previous restrictions.

Production of such fans has been limited to marine types for shipboard use since September 5, 1942. At the same time, sales of all fans in manufacturers' hands were prohibited except upon specific WPB authorization.

* * * *

Conservation of fuel for heating plants and buildings is always good business—in wartime, it is a patriotic duty! Uncle Sam wants you to save fuel—oil, coal, and gas.



ELECTRIC AIR CLEANING CONTROLS OIL MIST FROM MACHINE TOOLS

By E. H. R. Pegg

SUMMARY — Oil smoke and mist in the air of industrial plants is a wartime problem — and a nuisance, for several reasons. It reduces lighting efficiency and visibility, makes an unpleasant atmosphere in which to work, and — especially with wood construction—creates a fire hazard. . . . Electric air cleaning units may be used to remove oil from the air, reclaiming the oil for re-use; the air cleaning efficiency is such that the air may be recirculated to the space, thus saving heat in winter or refrigeration in summer. . . . The material given here has been taken from a paper presented at a recent machine tool forum by Mr. Pegg, engineer with the Westinghouse Electric and Mfg. Co.

A SERIOUS problem has arisen in industry during the past few years—the presence, in the air of certain manufacturing plants, of large amounts of oil smoke and mist. It is the result of three factors: (1) The higher operating speed of modern machine tools, such as automatic thread grinders and gear grinders, which causes part of the coolant oil to be broken up into a fine mist and, under some conditions, part of the oil to be volatilized; (2) the increase in the number of hours per day each machine is operated; and (3) the concentration of a large number of machines in one manufacturing space.

Oil mist and smoke in the air is a nuisance for several reasons. It lowers efficiency of lighting equipment and causes poor visibility. In severe cases it fogs the room and makes an unpleasant atmosphere in which to work. It condenses and settles out of the air to collect on floors, walls, overhead structures, lighting fixtures, and bus ducts—with the result that maintenance costs are greatly increased. In addition to the nuisance, a fire hazard is presented due to damage to electrical insulation and to the presence of oil on all parts of the building. This is particularly true in buildings of wood construction.

This problem can be overcome to some extent by simple ventilation alone—that is, dilution of the room air with large volumes of outside air. This, however, is prohibitively expensive because the large amount of outside air required causes excessive heat loss in winter and refrigeration loss in summer. Then, too, in most localities, unless the outside air is electrically cleaned, a large amount of dirt and dust will be taken into the building.

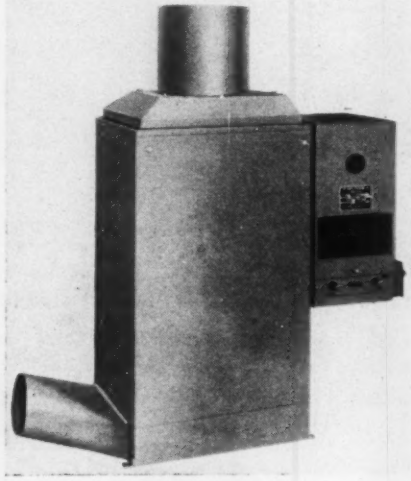
The solution of the problem is provided by the electric air cleaner. The high efficiency of electric air cleaning permits air so cleaned to be recirculated within the room.

One method of applying electric air cleaning to the problem of oil mist and smoke removal is the central air conditioning system. This method is highly satisfactory in keeping the concentration of oil mist and smoke so low that no visible haze is present in the room. It has one disadvantage, however, in that the oil mist must travel through the room in order to get to the openings of the return air ducts. In doing so, it can still condense or settle on surfaces and fixtures in the room.

The ultimate solution is the elimination of the mist and smoke at their source. This is done through ventilation of the machines themselves by providing hoods and exhaust ducts to pick up the mist and smoke before it can be spread into the room air.

In either system the air is taken from the machine, cleaned, and returned to the room at the same temperature. Thus there is no heat or refrigeration loss. The coolant which is removed from the air is collected by the electric air cleaning unit as a liquid and continuously runs back to the machine to be used again. In one case a small unit at one machine collected 4½ gal of oil in 24 hr. The average, however, is something like 1½ to 2 gal of oil in 24 hr.

An electric air cleaning unit for individual machine tools. Air containing oil mist from the machine is cleaned and returned to the room. This unit can be readily moved to accommodate any rearrangement of machines, as there is no overhead piping required



Applications of electric air cleaning for the ventilation of machine tools to date have been made on machines already in use. This involves the use of sheet metal hoods and ducts and a separate housing for the air cleaning equipment. In many types of machine tools it would be possible to design the machines to incorporate the ventilating system and electric air cleaner within the housing of the machine. This will require close cooperation between the manufacturers of machine tools and the manufacturers of electric air cleaners.

VENTILATION OF NEW CORNELL CHEMISTRY BUILDING

OLIN HALL of chemical engineering, new home of the school of chemical engineering at Cornell University, is the first building in a proposed new physical plant for the college of engineering.

All lecture rooms in Olin Hall are built without windows, the smaller ones being ventilated by thermostatically controlled unit ventilators which draw in air from outside the building; the foul air is vented through grilled ports into the building corridors. The larger lecture rooms are ventilated by forced ventilation, with the foul air exhausting into the corridors. Recitation rooms are also ventilated by unit ventilators in essentially the same way as are the small lecture rooms.

Fume hoods in the various laboratories are exhausted through nonmetallic ducts. The building is divided into three sections with all hoods in each section on a common outlet main. Each outlet main leads to a separate exhaust fan at the top of the building. The mains are carried just under the corridor ceilings and above a false ceiling made of removable steel panels.

General building ventilation is provided by an inlet fan in the basement which draws air from the outside through heating coils and discharges it into the basement corridors. This air passes through into the corridors of the building and is discharged through the various hood vents in the individual rooms. This maintains a slight positive pressure inside the building and an inward flow of air to each laboratory from the corridor.

The one big laboratory for unit operations, which extends through three floors, is heated by blast heaters at the ceiling level.

WATER SPRAYED DIRECT EXPANSION COILS

• Their Theory and Characteristics •

Although Used Extensively in the Manufacture and the Testing of War Goods, the Fundamentals of Such Coils Have Never Before Been Analyzed as Completely as in This Treatment by William Goodman

OUR DISCUSSION of the theory and characteristics of water sprayed direct expansion coils is continued from the April HPAC:

Computing Capacity of a Given Coil

The method of computing the capacity of a coil and the temperature of the spray water can best be illustrated by means of an example.

Example 1—A coil having an external area A of 500 sq ft is to be used to cool 5000 cfm of air. The initial wet bulb temperature of the air is 70 F and the temperature of the refrigerant is 40 F. The barometric pressure is 29.92 in. Hg and the density of the air is 0.075 lb per cu ft. For this coil, $R = 6$. The coefficients of heat transfer are as follows: $f_s = 10$, $f_w = 50$, and $f_R = 300$. Find (a) the temperature of the spray water; and (b) the refrigerating capacity of the coil.

Solution—

a) Using equation 4,

$$\frac{1}{U} = \frac{1}{50} + \frac{6}{300}$$

$$U = 25$$

The weight of air to be cooled is $G = 5000 \times 60 \times 0.075 = 22{,}500$ lb per hr.

Using equation 2,

$$M = \frac{10 \times 500}{0.24 \times 22{,}500} = 0.93$$

Referring to Table 1 for $M = 0.93$, $Z = 0.6055$.

Using equation 6,

$$N = \frac{25 \times 500}{0.6055 \times 22{,}500} = 0.918$$

Referring to Table 2 for $N = 0.918$, $\theta = 56°\text{-}6'$. Using Fig. 3 for $t_R = 40$ F and $t'_1 = 70$ F, $t_w = 53.1$ F.

b) The refrigerating capacity of the coil can be computed by means of either equation 1 or 3; as a check, both will be used.

From part (a) of this example, $Z = 0.6055$. From Table 5, for $t'_1 = 70$ F, $h_1 = 44.03$; and for $t_w = 53.1$ F, $h_w = 32.05$.

Using equation 1, $Q = 22{,}500\ (44.03 - 32.05)\ 0.6055 = 163{,}200$ Btu per hr.

Using equation 3, $Q = 25\ (53.1 - 40)\ 500 = 163{,}800$ Btu per hr.

The discrepancy in the results obtained by means of equations 1 and 3 amounts to less than one-half of 1 per cent and is due only to rounding off of the last digits.

Refrigerating capacity of coil = $163{,}200 \div 12{,}000 = 13.6$ tons.

Rating of Sprayed Coils

The problem of rating sprayed coils is different from the one of selecting such coils for a specific application. In this section, only the rating of coils will be discussed. In a later section, the problem of selecting sprayed coils for a specific application will be presented with illustrative examples and curves.

In rating coils for a variety of operating conditions, one convenient method is to prepare tables or curves for definite entering air wet bulb temperatures and for definite refrigerant temperatures. With this method, the performance of the coil for different ratios of air volume to cooling surface is of considerable interest because of its very marked effect on the performance and refrigerating capacity of the coil. In addition, the effect of the various heat transfer coefficients on the performance must be known if coils are to be rated intelligently.

The curves in Fig. 5 show the relationship between the coil area and the air quantity required for various values of the air film coefficient f_s and the water-to-refrigerant coefficient U. The curves show that there is no material advantage in increasing the cfm per ton beyond some such point like B. The decrease in surface with any further increase in cfm is practically negligible. The curves also show that there is no advantage in increasing the amount of surface required beyond that shown at some such point like A. Any further increase in surface has little effect on the air quantity required. Consequently coils should ordinarily be selected to operate at some point which lies between points like A and B of Fig. 5.

At a point like A of Fig. 5, the effect of the air film coefficient f_s on performance is relatively small. Notice that for values of f_s ranging as widely as from 10 to infinity, the va-

Copyright, 1943, by William Goodman.

SUMMARY—Sprayed direct expansion coils are widely used in air conditioning and refrigeration work. Coils sprayed with water are used in air conditioning, and brine sprayed coils are, of course, used in low temperature air conditioning and refrigeration installations. Because such coils are used extensively today for all kinds of manufacturing and testing in connection with the war effort, a fundamental treatment of their theory and characteristics is especially timely. In spite of the fact that such coils have been used for many years, such a treatment has never before been published. . . . In the article of which this is the second part, the theory and characteristics of water sprayed coils are covered in a simple and thorough fashion with many illustrative examples to show not only how the characteristics of such coils are computed, but also to show the effect of variations in the various quantities which affect the performance. A thorough understanding of the basic characteristics and theory of sprayed coils should result in much more efficient and satisfactory installations. . . . Mr. Goodman is consulting engineer, the Trane Co., and a member of HPAC's board of consulting & contributing editors

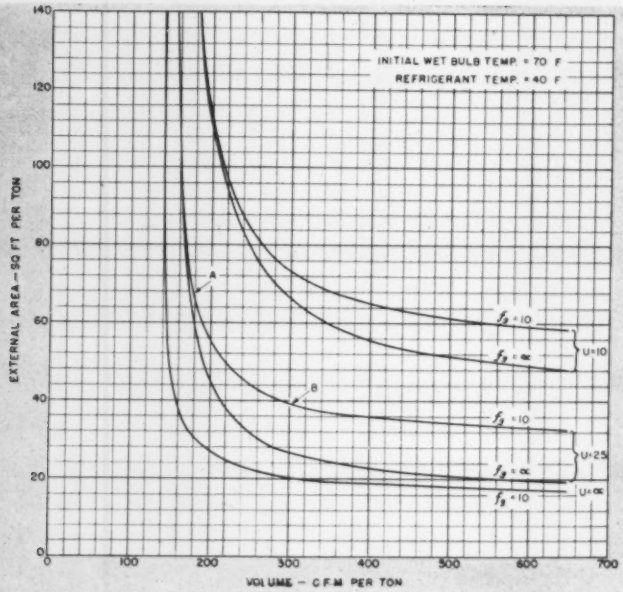
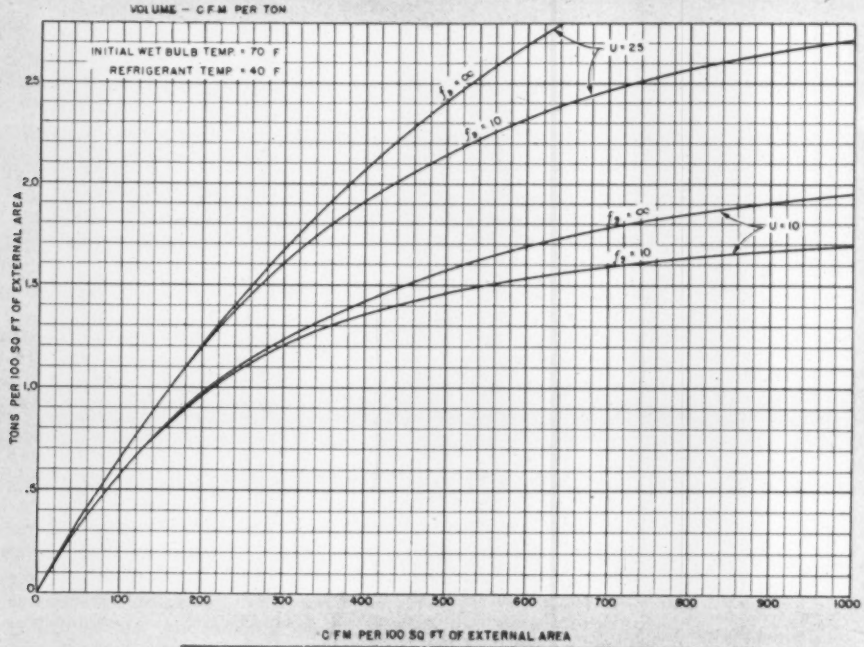
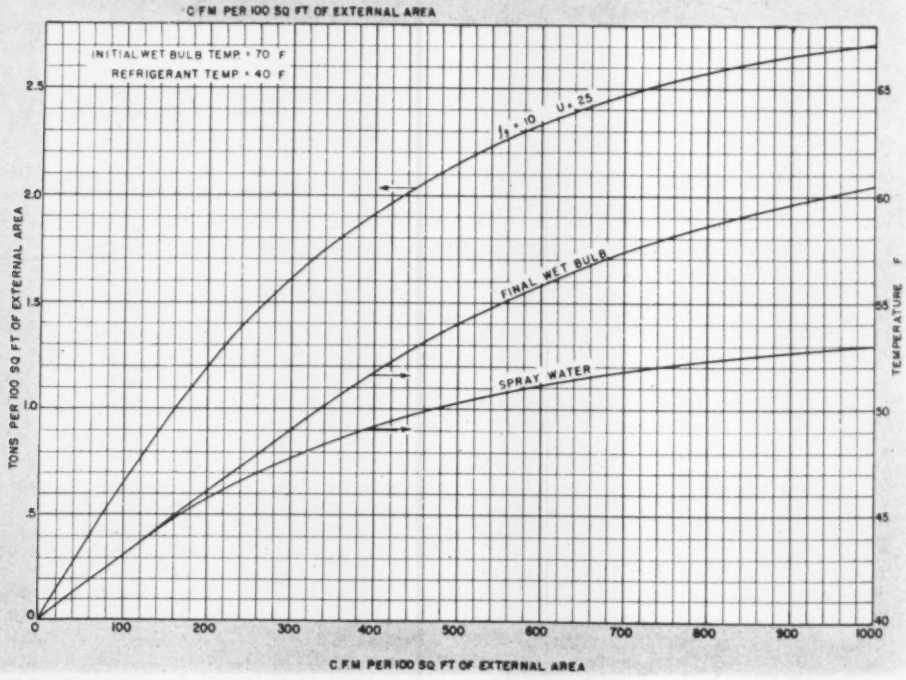


Fig. 5 (top)—Variation in area and cfm per ton for coils having various heat transfer coefficients

Fig. 6 (center)—Variation in capacity and cfm per 100 sq ft of external area for coils having various heat transfer coefficients

Fig. 7 (bottom)—Variation in capacity and final wet bulb temperatures for a given coil


INITIAL WET BULB TEMP. = 70 F
REFRIGERANT TEMP. = 40 F
TONS PER 100 SQ FT OF EXTERNAL AREA
C.F.M. PER 100 SQ FT OF EXTERNAL AREA
f_g = ∞
f_g = 10
U = 25
U = 10


INITIAL WET BULB TEMP. = 70 F
REFRIGERANT TEMP. = 40 F
TONS PER 100 SQ FT OF EXTERNAL AREA
TEMPERATURE F
C.F.M. PER 100 SQ FT OF EXTERNAL AREA
f_g = 10
U = 25
FINAL WET BULB
SPRAY WATER

riation in the amount of surface required per ton is small compared to the variation in the value of f_g. For the finite variations in the values of f_g such as are obtainable in actual apparatus, the variation in the amount of surface required per ton for large variations of f_g is almost negligible at a point like A. Whatever variation there is occurs only for large air quantities per ton. For small air quantities, the curves for values of f_g ranging from 10 to infinity practically coincide.

For small values of U, variations in its value have a considerable effect on the amount of surface required. For example, at the low air volumes of about 200 to 300 cfm per ton, the variation in surface required with changes in values of U from 10 to 25 is large. However, for large values of U, the variation becomes correspondingly less. Notice, for example, that for values of U ranging from 25 to infinity the change in the surface required is considerably smaller than the change in surface required for values of U from 10 to 25.

Curves like those of Fig. 5 are of value in studying coil performance because they clearly show the relationship between air quantity, coil surface, and various heat transfer coefficients. The method of computing the points for these curves is illustrated by the following example. In this example, first some value of A/G (sq ft of surface per lb of air per hr) is chosen at random. Then G/Q, which is lb of air per Btu (from which cfm per ton may be computed), is found by means of equation 1. Then multiplying G/Q by A/G yields A/Q, area per Btu per hr, from which sq ft of surface per ton may be computed.

Example 2—Select at random a value of A/G equal to 0.0445 and compute the required area and cfm per ton. The initial wet bulb temperature of the air is to be 70 F and the refrigerant temperature is 40 F. Assume $f_g = 10$ and $U = 25$.

Table 3—Values of M for Values of Z

Z	M	Z	M	Z	M
0.00	0.00000	0.35	0.4308	0.70	1.204
.01	.01005	.36	.4463	.71	1.238
.02	.02020	.37	.4620	.72	1.273
.03	.03046	.38	.4780	.73	1.309
.04	.04082	.39	.4943	.74	1.347
0.05	0.05129	0.40	0.5108	0.75	1.386
.06	.06188	.41	.5276	.76	1.427
.07	.07257	.42	.5447	.77	1.470
.08	.08338	.43	.5621	.78	1.514
.09	.09431	.44	.5798	.79	1.561
0.10	0.1054	0.45	0.5978	0.80	1.609
.11	.1165	.46	.6162	.81	1.661
.12	.1278	.47	.6349	.82	1.715
.13	.1393	.48	.6539	.83	1.772
.14	.1508	.49	.6733	.84	1.833
0.15	0.1625	0.50	0.6931	0.85	1.897
.16	.1744	.51	.7133	.86	1.966
.17	.1863	.52	.7340	.87	2.040
.18	.1985	.53	.7550	.88	2.120
.19	.2107	.54	.7765	.89	2.207
0.20	0.2231	0.55	0.7985	0.90	2.303
.21	.2357	.56	.8210	.91	2.408
.22	.2485	.57	.8440	.92	2.526
.23	.2614	.58	.8675	.93	2.659
.24	.2744	.59	.8916	.94	2.813
0.25	0.2877	0.60	0.9163	0.95	2.996
.26	.3011	.61	0.9416	.96	3.219
.27	.3147	.62	0.9676	.97	3.507
.28	.3285	.63	0.9943	.98	3.912
.29	.3425	.64	1.022	.99	4.605
0.30	0.3567	0.65	1.050	1.00	Inf
.31	.3711	.66	1.079		
.32	.3857	.67	1.109		
.33	.4005	.68	1.139		
.34	.4155	.69	1.171		

Solution—Using equation 2, $M = (10/0.24) \times 0.0445 = 1.85$.

From Table 1 for $M = 1.85$, $Z = 0.8428$. Using equation 6, $N = (25/0.8428) \times 0.0445 = 1.32$.

Referring to Table 2 for $N = 1.32$, $\theta = 64°\text{-}54'$. Using the water-air chart of Fig. 3, for $t'_1 = 70$ F and $t_R = 40$ F, $t_w = 50.3$ F. From Table 5, for $t'_1 = 70$ F, $h_1 = 44.03$, and for $t_w = 50.3$ F $h_w = 30.44$. From equation 1, $Q/G = (44.03 - 30.44)\ 0.8428 = 11.45$. Hence $G/Q = 1/11.45 = 0.0873$.

To transform G/Q to cfm per ton,

$$\text{Cfm per ton} = \frac{12{,}000}{60 \times 0.075} \frac{G}{Q}$$

$$= 2667 \times 0.0873$$

$$= 233 \text{ cfm per ton.}$$

$$\frac{A}{Q} = \frac{A}{G} \times \frac{G}{Q}$$

$$= 0.0445 \times 0.0873$$

$$= 0.00388 \text{ sq ft per Btu per hr}$$

To transform A/Q to sq ft per ton, sq ft per ton $= 12{,}000 \times 0.00388 = 46.6$ sq ft per ton.

The points required to plot the various curves in Fig. 5 were computed by the method illustrated by the foregoing example.

Testing of Coils

In testing coils to determine the values of f_g, the curves of Fig. 5 show that the tests should be performed for rather large values of cfm per ton if f_g is to be determined with a reasonable degree of accuracy. Although a high degree of accuracy is not necessary, the values of f_g should be known as closely as possible if agreement is to be obtained between the actual field performance and the rating. However, the curves of Fig. 5 show that it would be impossible to obtain values of f_g with any kind of accuracy at low values of cfm-per-ton because the performance curves for a large range in values of f_g merge at low air quantities.

From test data, the value of f_g can be determined by means of equation 1. All of the quantities, such as total heat transferred, spray water temperature, initial wet bulb temperature, air quantity, and surface area, are measured. Equation 1 is used to find

Symbols

A = area, in sq ft;
c = 0.24, specific heat of air;
f_g = coefficient of heat transfer between air and water (through air film), Btu per hr per deg per sq ft;
f_R = coefficient of heat transfer between wall of metal tube and evaporating refrigerant (refrigerant film coefficient), Btu per hr per deg per sq ft;
f_w = coefficient of heat transfer between water and metal wall of tube (water film coefficient), Btu per hr per deg per sq ft;
G = weight of dry air through coil, lb per hr;
h_1 = initial enthalpy (total heat content) of air entering sprayed coil, Btu per lb of dry air;
h_w = enthalpy (total heat content) of saturated air at a temperature equal to the temperature of the spray water, Btu per lb of dry air;
M = a quantity defined by equation 2;
N = a quantity defined by equation 6;
N_L = limiting value of N as defined by equation 8;
Q = total quantity of heat removed from the air, Btu per hr;
t_R = temperature of refrigerant, F;
t_w = temperature of spray water, F;
t'_1 = initial wet bulb temperature of air, F;
U = overall coefficient of heat transfer from spray water to evaporating refrigerant, Btu per hr per deg per sq ft (defined by equation 4);
Z = a quantity that depends on M (see Table 1);
θ = angle on spray water-air chart (see Fig. 4).

the value of Z. Then by means of Table 3, the value of M is found. With the value of M known, the value of f_s can be found from equation 2.

Values of U can, of course, be determined from the same test quite simply by means of equation 3. For any one refrigerant, it is unnecessary to resolve the value of U into its component coefficients f_w and f_R as shown by equation 4. However, if the coil is to be used with a refrigerant different from the one which was used in the test, then the coefficients f_w and f_R must be known. The commonest method of breaking U down into f_w and f_R is to use previously published or previously determined values of f_R. With the value of U obtained from test and the value of f_R known, the value of f_w, the heat transfer coefficient between the spray water and the pipe wall, can then be determined by means of equation 4.

There is no fixed rule as to the amount of spray water to use during a test, or—for that matter—the amount to use for an actual installation. Fundamentally, only enough spray water is required to keep the heat transfer surfaces thoroughly wetted. However, the value of f_w, the heat transfer coefficient from the water to the heat transfer surface, does vary with the quantity of spray water passing over the heat transfer surface. Hence, when selecting the quantity of spray water, it is necessary to consider the effect of the rate of water flow upon the heat transfer coefficient.

Variation in Coil Capacity With Heat Transfer Coefficients

Fig. 6 shows the variation in capacity of a given coil with variations in the values of f_s, U, and variations in cfm. From this figure, it is also apparent that at low air volumes large variations in the value of f_s have little effect on the capacity of the coil in terms of tons per unit of external area. As the air quantity increases, there is some variation in capacity with an increase in the value of f_s, the air film coefficient. However, notice that even at 400 cfm per 100 sq ft—and for a value of U equal to 25—that the change in capacity is only from 1.92 to 2.07 tons for a range of f_s as large as from 10 to infinity. Now the value of f_s, the air film coefficient, will rarely be large. Consequently, it is obvious that the variation in f_s with air velocity is not of much importance in determining the final capacity of a coil at air volumes below about 400 cfm per ton.

On the other hand, the value of U does have a relatively large effect on capacity, as is evident from Fig. 6. Consequently, this value should be determined accurately and the coil so designed as to obtain as large a value of U as possible.

Although infinite values of f_s cannot, of course, be obtained, curves for this value are useful for showing the maximum capacity obtainable with increasing quantities of air. The computation of the curves in Figs. 5 and 6 where f_s is infinite is no different than the computation for finite values of G. From equation 2 for an infinite value of f_s, M is also infinite. Referring to Table 1 for M equal to infinity, $Z = 1$. First substitute $Z = 1$ into equation 5. The balance of the computations for the curves in Figs. 5 and 6 is then carried out in the manner illustrated in example 2.

Maximum Refrigerating Capacity of Coil

As the quantity of air is increased, the capacity of a sprayed cooling coil increases. However, as the quantity of air is increased, the temperature of the spray water and the final wet bulb temperature of the air also increase as shown in Fig. 7. As the air quantity increases indefinitely, both the temperature of the spray water and the capacity in tons per 100 sq ft approach some limiting value. The maximum spray water temperature and the maximum capacity of the coil are reached when the quantity of air supplied is infinite.

At low air quantities, both the capacity and the temperature of the spray water increase rapidly for a small change in air quantity. However, at large air quantities, the increase in water temperature and the increase in the capacity of the coil are negligibly small. The maximum capacity of the coil is obtained when the temperature of the spray water is a maximum. Although the capacity of a coil with an infinite quantity of air is of no practical significance, this capacity is of value in indicating the maximum capacity which can be obtained from any given coil.

In order to find the maximum possible capacity of a coil as the air quantity is made infinitely large, it is first necessary to determine the maximum possible spray water temperature. The temperature of the spray water depends, of course, upon the value of N in equation 7. It will be found that as the value of N decreases, the temperature of the spray water increases. For the maximum spray water temperature, there is a minimum value of N which is obtained when the air quantity is infinite. This minimum value of N cannot be calculated from equation 6 because when G is infinite, this equation becomes indeterminate. Instead it is necessary to use another formula obtained from equation 6.

The minimum value of N for an infinite quantity of air can be computed from the following equation, which is derived from equation 6 in the manner shown in appendix 3 on p. 328 of the May, 1938, HPAC.[4] The equation to be used in computing N for an infinite quantity of air is

$$N_L = \frac{0.24U}{f_s} \quad \text{.....[8]}$$

In the foregoing formula the subscript L is used to show the limiting

Table 4—Values of M and Z for Values of the Ratio N_L/N

N_L/N	M	Z	N_L/N	M	Z
0.25	3.920	0.9801	0.65	0.9338	0.6069
.26	3.758	.9767	.66	.8976	.5925
.27	3.603	.9728	.67	.8625	.5779
.28	3.461	.9686	.68	.8280	.5631
.29	3.324	.9640	.69	.7943	.5481
0.30	3.197	0.9591	0.70	0.7615	0.5330
.31	3.078	.9540	.71	.7290	.5176
.32	2.964	.9484	.72	.6973	.5021
.33	2.857	.9426	.73	.6663	.4864
.34	2.754	.9363	.74	.6358	.4705
0.35	2.657	0.9298	0.75	0.6058	0.4544
.36	2.564	.9230	.76	.5765	.4381
.37	2.476	9159	.77	.5476	.4217
.38	2.391	.9085	.78	.5194	.4051
.39	2.310	.9007	.79	.4915	.3883
0.40	2.232	0.8927	0.80	0.4643	0.3714
.41	2.157	.8843	.81	.4373	.3542
.42	2.085	.8757	.82	.4110	.3370
.43	2.016	.8668	.83	.3850	.3196
.44	1.949	.8576	.84	.3595	.3020
0.45	1.885	0.8482	0.85	0.3344	0.2842
.46	1.823	.8385	.86	.3096	.2663
.47	1.763	.8285	.87	.2853	.2482
.48	1.704	.8180	.88	.2614	.2300
.49	1.648	.8076	.89	.2378	.2116
0.50	1.594	0.7969	0.90	0.2145	0.1930
.51	1.541	.7858	.91	.1917	.1744
.52	1.489	.7744	.92	.1692	.1557
.53	1.440	.7631	.93	.1468	.1365
.54	1.391	.7512	.94	.1250	.1175
0.55	1.344	0.7392	0.95	0.1036	0.0984
.56	1.298	.7269	.96	.0823	.0790
.57	1.254	.7146	.97	.0613	.0595
.58	1.210	.7018	.98	.0406	.0398
.59	1.168	.6890	.99	.0200	.0198
0.60	1.126	0.6757	1.00	0	0
.61	1.086	.6624			
.62	1.047	.6490			
.63	1.008	.6351			
.64	0.9705	.6211			

value of N; that is, the lowest value of N that can be obtained. Using the limiting value of N computed by means of equation 8, together with Table 2 and Fig. 3, the maximum possible spray water temperature can be found. The maximum refrigerating capacity of the coil can then be found by substituting this maximum spray water temperature into equation 3. Equation 1 should not be used for determining the maximum coil capacity, because for an infinite value of G this equation becomes indeterminate.

The method of determining the theoretical maximum spray water temperature and the maximum coil capacity is illustrated by the following example.

Example 3—Take the conditions of example 2 and find the maximum spray water temperature and the maximum refrigerating capacity of the coil.

Solution—Using equation 8,

$$N_L = \frac{0.24 \times 25}{10} = 0.6$$

From Table 2, for $N_L = 0.6$, $\Theta = 44°\text{-}9'$. Using Fig. 3, it is found that the maximum possible spray water temperature is $t_w = 56.6$ F. Using equation 3,

$$\frac{Q}{A} = 25 \quad (56.6 - 40) = 415 \text{ Btu}$$

per hr per sq ft of surface, maximum capacity.

Maximum refrigerating capacity $= \frac{100}{12{,}000} \times \frac{Q}{A} = 3.46$ tons per 100 sq ft.

Notice in Fig. 7 that as the air quantity is increased, the temperature of the spray water and the capacity of the coil approach the values found in the foregoing example. Notice also that the final wet bulb temperature of the air approaches 70 F, the temperature given in the example as the initial wet bulb temperature. This is to be expected because, regardless of the capacity of the coil, there can be no change in the wet bulb temperature of the air with an infinite quantity of air.

The maximum capacity of the coil can never, of course, be obtained in actual practice, but a computation of the foregoing type is interesting because it indicates the limiting tonnage that can theoretically be obtained from a coil for a given entering wet bulb temperature and refrigerant temperature. Example 3 is also of interest because it shows the minimum amount of surface required per ton. For example, inasmuch as the maximum tonnage is 3.46 tons per 100 sq ft, the minimum surface required is 100/3.46 or 28.9 sq ft of surface per ton. The actual amount of surface that must be used is, of course, greater but a knowledge of the theoretical minimum is of value in designing and selecting such coils.

When the surface is increased indefinitely, the cfm per 100 sq ft becomes equal to zero. When this occurs, as is to be expected and as can be shown by means of equation 5, the final wet bulb temperature and the spray water temperature both become equal to the temperature of the refrigerant. In Fig. 7, notice that when the cfm per 100 sq ft is zero, the final wet bulb temperature of the air and the spray water temperature both pass through 40 F, the given refrigerant temperature.

The value of N can also be computed by means of data in the third column of Table 1. For example, after M has been found by means of equation 2, the values of Z and the ratio N_L/N corresponding to the computed value of M can be found in Table 1. The value of N can then be computed by means of equation 6. Knowing the value of N and the ratio N_L/N, the value of N_L can be found directly. For instance, in example 2, $M = 1.85$ and $N = 1.32$. Referring to Table 1 for $M = 1.85$, the ratio $N_L/N = 0.4555$. Consequently, $N_L = 1.32 \times 0.4555 = 0.601$. In example 3, which was also based on example 2, the value of N_L computed by means of equation 8 was found to be 0.6.

Computing Surface or Air Quantity

The maximum spray water temperature corresponding to the limiting quantity N_L can be found only by means of Fig. 3 as illustrated in the preceding example. Fig. 3 has also been used to find the spray water temperature for higher values of N. For instance, in example 2 the value of A/G was assumed and Fig. 3 was used to find the spray water temperature. By using N_L it is possible to reverse the procedure illustrated in example 2—that is, the spray water temperature can be assumed first and the ratio A/G found. This has not heretofore been possible because equation 5 as it stands now cannot be solved for A/G due to the fact that the value of A/G also appears in the equation used for defining Z.

Summarizing, Fig. 3 is used to find the spray water temperature for a given value of A/G. On the other hand, the method about to be described is used to find the value of A/G for a given spray water temperature and refrigerant temperature.

After assuming the spray water temperature, equation 7 (repeated below for convenience) is used to determine the value of N for a given initial wet bulb temperature and refrigerant temperature.

$$\frac{h_1 - h_w}{t_w - t_R} = N$$

Second, the value of N_L is determined by means of equation 8. The ratio N_L/N can now be computed. Then, by using Table 4, the value of M corresponding to the computed value of N_L/N can be determined. From the value of M, the ratio A/G can be computed by means of equation 2. The basis for this method is explained below[7] [footnote on next page].

The following example illustrates the method of using the ratio N_L/N to determine the value of A/G for any assumed spray water temperature whose value lies between the refrigerant temperature and the maximum spray water temperature.

Example 4—Take the conditions of example 2 and find the value of A/G required if the spray water temperature is to be 48 F.

Solution—Using equation 7,

$$N = \frac{44.03 - 29.18}{48 - 40} = 1.86$$

Using equation 8,

$$N_L = \frac{0.24 \times 25}{10} = 0.6$$

$$\frac{N_L}{N} = \frac{0.6}{1.86} = 0.323$$

Table 5—Total Heat of Saturated Air 29.92 In. Hg Barometer Btu Per Lb of Dry Air

Temperature F	Enthalpy (Heat Content)
30	20.93
31	21.33
32	21.74
33	22.15
34	22.57
35	22.99
36	23.42
37	23.86
38	24.30
39	24.75
40	25.21
41	25.67
42	26.15
43	26.63
44	27.12
45	27.62
46	28.13
47	28.65
48	29.18
49	29.72
50	30.27
51	30.84
52	31.41
53	31.99
54	32.58
55	33.19
56	33.81
57	34.44
58	35.09
59	35.75
60	36.42
61	37.11
62	37.81
63	38.53
64	39.26
65	40.02
66	40.78
67	41.57
68	42.37
69	43.19
70	44.03
71	44.89
72	45.77
73	46.67
74	47.59
75	48.53
76	49.50
77	50.49
78	51.50
79	52.54
80	53.60

Total heat values are from the author's book, Air Conditioning Analysis.

[7] In the present article $N = UA/GZ$, whereas in the article in the May, 1938, HPAC, N is defined as GZ/UA. This accounts for the difference in the definitions of N, in these two articles. However, the derivation in the May, 1938, HPAC is valid for both definitions of N_L.

Referring to Table 4 for $N_L/N = 0.323$, $M = 2.932$.

Using equation 2,

$$\frac{A}{G} = \frac{0.24}{f_s} M$$

$$= \frac{0.24}{10} \times 2.932$$

$$= 0.0704 \text{ sq ft per lb of air per hr}$$

$$\text{Sq ft per cfm} = \frac{60}{13.33} \frac{A}{G}$$

$$= 4.5 \times 0.0704$$

$$= 0.317$$

$$\text{Cfm per 100 sq ft} = \frac{100}{0.317} = 315$$

cfm per 100 sq ft of surface.

Knowing the value of A/G and the spray water temperature, the value of Q/G can be found by means of equation 1, using either Table 1 or Table 4 to determine the value of Z.

The limits of the spray water temperature should, of course, be determined in advance so that a spray water temperature that is impossible to obtain will not be assumed in solving A/G by the method illustrated in the foregoing example. The lowest possible spray water temperature is equal to the refrigerant temperature. The maximum possible spray water temperature is determined by means of equation 8 as illustrated in example 3. The assumed spray water temperature should, of course, lie between these two values.

---

[1]According to Equation 6,

$$N = \frac{UA}{GZ} \quad \ldots\ldots\ldots\ldots\ldots\ldots [a]$$

Multiplying both sides of equation [a] by f_s/cU,

$$\frac{f_s}{cU} N = \frac{f_s A/cG}{Z} \quad \ldots\ldots\ldots\ldots\ldots [b]$$

But, from equation 2,

$$M = \frac{f_s A}{c G} \quad \ldots\ldots\ldots\ldots\ldots\ldots [c]$$

and, from equation 8,

$$N_L = \frac{cU}{f_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots [d]$$

Substituting [c] and [d] into [b],

$$\frac{N_L}{N} = \frac{Z}{M} \quad \ldots\ldots\ldots\ldots\ldots\ldots [e]$$

The values of N_L/N in Tables 1 and 4 were computed by means of equation (e). In connection with the computations of these tables it is necessary to know that

$$Z = (1 - e^{-M}),$$

where e = base of natural logarithms.

HEAT TRANSFER COEFFICIENTS FOR ROOF CONSTRUCTIONS

THE EDITOR—

Attached is a rough sketch [not reproduced] of a roof on a temporary building for which I am desirous of determining the coefficient of heat transfer.

The specifications of the roof as it is now, are: purlins, 3 x 10 pine, on 24 in. centers; roof deck, ⅞ North Carolina pine roofers, tongue and grooved; roofing, one layer 65 lb felt tacked to deck and mopped one coat and a second layer laid over and mopped. It is proposed to apply either ⅞ in. North Carolina T & G roofers or ½ in. wallboard to the under side of the purlins and to install 2 in. of balsam wool insulation over this material.

I will greatly appreciate the assistance you will render me if you will calculate for me the value of U for the existing and for both of the proposed roof constructions and let me have the calculations. In general I know the procedure for the calculations but am uncertain of the values to use as this branch of engineering is but one of many with which I come in daily contact.

The reason that I am imposing upon you for this information is that I am a charter subscriber to Heating, Piping & Air Conditioning, and I can depend upon the accuracy of your information.—G.E.W., superintendent of rail equipment & power.

REPLY—

The average or weighted coefficient of transmission of the roof based on the present specifications is 0.42 Btu per hr per sq ft per F temperature difference. If a ½ in. thickness of insulating board is applied to the under side of the rafters the weighted coefficient will be about 0.20. If in addition, a 2 in. thickness of balsam wool is applied as specified, the coefficient will be 0.083. These coefficients are derived as follows; in the denominator of each calculation, we start with the outside surface and end with the inside surface, following the roof constructions through in their order.

The coefficient of transmission of the roof between the rafters or "purlins" based on the present specifications (without insulation) is:

$$U = \frac{1}{\frac{1}{6.0} + \frac{1}{3.53} + \frac{0.875}{0.80} + \frac{1}{1.65}}$$

$$= 0.465$$

The coefficient of transmission through the rafters only is:

$$U = \frac{1}{\frac{1}{6.0} + \frac{1}{3.53} + \frac{0.875}{0.80} + \frac{9.625}{0.80} + \frac{1}{1.65}} = 0.071$$

The actual width of the 3 in. x 10 in. purlins is 2⅝ in. (2.625) and since they are spaced on 24 in. centers, the area covered by the purlins is (2.625/24) x 100, or about 11 per cent of the total. The weighted coefficient therefore will be:

$$U_w = 0.89 \times 0.465 + 0.11 \times 0.071 = 0.42$$

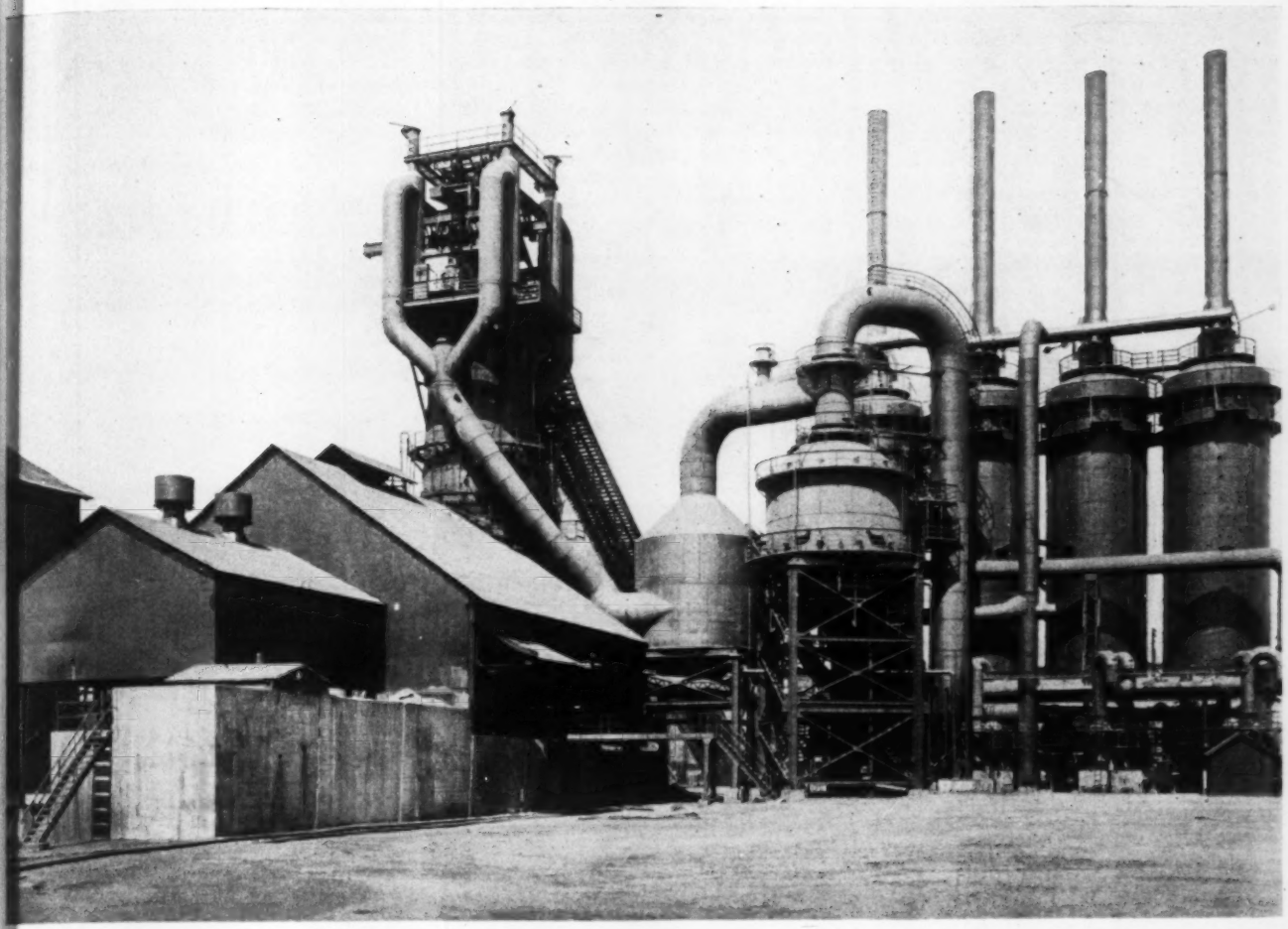
If ½ in. insulating board is applied to the under side of the purlins, the coefficient of transmission (between the purlins) will be 0.22, and 0.06 at the purlins, and weighted coefficient will be $0.89 \times 0.22 + 0.11 \times 0.06$ or 0.20.

With ½ in. insulating board and 2 in. balsam wool, the coefficient of transmission of the roof between the purlins will be:

$$U = \frac{1}{\frac{1}{6.0} + \frac{1}{3.53} + \frac{0.875}{0.80} + \frac{1}{1.10} + \frac{2.0}{0.27} + \frac{0.5}{0.33} + \frac{1}{1.65}} = 0.083$$

The weighted coefficient will be only slightly less, or 0.081.—PAUL D. CLOSE, technical secretary, Insulation Board Institute.

GIVE TO THE RED CROSS WAR FUND



A southern merchant blast furnace

"BONE DRY" or "THREE GRAINS"?

Ralph H. Sweetser, Consultant on Blast Furnace Practice, Explains Need for Conditioning the Air for Blast Furnaces

SUMMARY—Air is the weightiest and most voluminous of the raw materials used in the production of pig iron—and pig iron is today the basis of our entire steel industry. The importance of the proper condition of that air to our war effort and to American industry in the postwar period to come is thus self-evident ....When blast furnace air conditioning is discussed, controversy rages between advocates of "bone dry" air or that with a moisture content of three grains per cubic foot. As Mr. Sweetser points out here, if one moisture content is found best for some certain locality and a certain combination of conditions, it does not necessarily follow that it would also be the optimum amount for some other blast furnace in a different locality and with different conditions. Like all problems in which the laws of nature are involved, the right answer depends upon engineering analysis of the pertinent facts

AS FAR as weather conditions are concerned, the iron blast furnace is more sensitive to changes in the weather than the most delicate watch. A well-adjusted watch is not disturbed by a sudden shift in the wind, a rapid drop of the barometer, or a rise of the thermometer—but a blast furnace's digestion is much upset by such irregularities when using the natural atmosphere for its air blast.

Air Is Heaviest Raw Material for Pig Iron

Air is the weightiest and most voluminous of the raw materials used in the production of pig iron. The tons of atmospheric air used to make 1 ton of pig iron vary, in this country, from about 3 tons under the most favorable conditions as to coke and richness of ore burden, up to about 4 tons where the ore is lean and the coke none too good. The total solid materials—iron ore, coke, and limestone—going into a blast furnace to make 1 ton of pig iron under the same conditions would be 2½ tons and 4½ tons respectively. Hence, the importance of the air blast and its physical qualities is easily realized.

It is well known that the "humidity," as it is generally understood by the public, is greater in summer than in winter, and there grew up the idea that a blast furnace used more coke per ton of pig iron and made less tonnage in the summer months than during the winter. Part of this decrease in tonnage was due to less oxygen in an equal volume of air at 90 F in summer than in air at 20 F in winter. Gradually this deficiency was overcome by blowing more volume of blast in the warmer months at the rate of 2 per cent increase of

blast volume to each 10 deg rise in the outdoor temperature. This method, of course, still further increased the amount of water in the blast per ton of pig iron.

Chilling Effect on Hearth Temperature

Much has been said about the "chilling effect" of the dissociation of the moisture in the hot blast in the hearth of the furnace; it is true that such an endothermic reaction takes place, but it is trivial when compared with the cooling effect of the dissociation of the CO_2 that is instantly formed at the nose of the tuyeres by the combustion of incandescent coke and the oxygen of the blast, and then instantaneously broken up into two volumes of CO gas with an appalling loss of heat. Within the hearth of the iron blast furnace there is nothing quiet, nothing static—and "almost anything can happen." The chilling effect of the endothermic reaction of carbon dioxide plus incandescent coke ($CO_2 + C = 2\ CO$) is overcome by the net results of the sensible heat of the hot blast and the combustion of the coke.

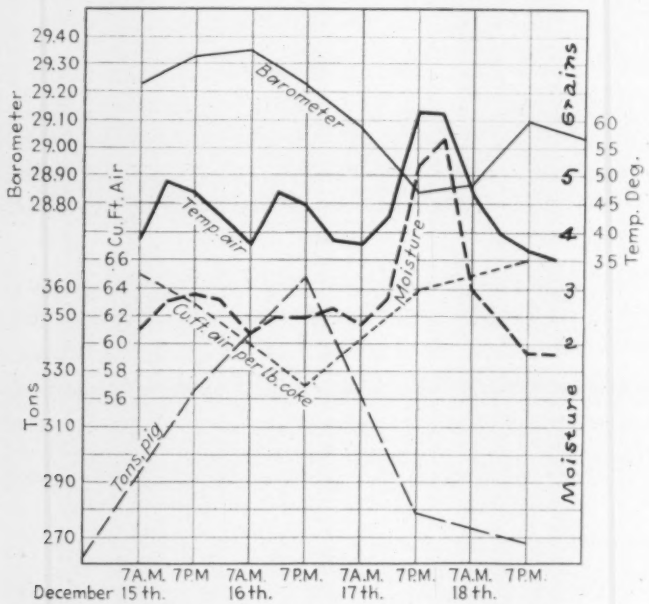
The Dry Blast Process

However, the dissociation of the moisture in the air blast does have an immediate chilling effect on the temperature of the hearth, and there must be some source of heat to balance this loss. Based on this apparent completely detrimental chilling effect, there arose the theory that all moisture should be eliminated and the "dry blast" process of James Gayley came into practice in the summer of 1904 with truly phenomenal results. The savings in fuel per ton of pig iron were greater than could be accounted for simply on the theory of the elimination of moisture and its dissociation losses. The controversial arguments on both sides of the Atlantic, as published in the transactions of the iron and steel institute, make interesting reading, even though they contain much misinformation. The complete freezing out of all moisture in the air blast was not the right answer to the problem.

Amount of Moisture in Blast

In spite of the fact that the Gayley dry blast system is not now used in this country, there have been recent attempts to get "bone dry" air blast by other means. Where such systems were installed there were sometimes unsatisfactory results that could not be fully corrected until more moisture was left in the air blast. Of the two present schools of air blast conditioning, i.e., the "bone dry" and the "three grains," it is likely that the latter is nearer right; but even if three grains of moisture per cubic foot of air should be found best for some certain locality and a certain combination of conditions it does not follow that three grains would be the optimum amount of moisture for some other blast furnace in another locality and with different conditions. These conditions include the kind of coke and the source of the coking coal, the ore mixture, the location of the blast furnace, and the weather conditions throughout all the seasons of the year.

When the author took charge of a Canadian blast furnace plant, he thought he was going to have ideal air conditioning because those furnaces were the nearest to the North Pole of any on this continent. The surprising thing was that the best results as to lower fuel consumption were not in the winter months, even when the average temperature of the outdoor air for a whole month was as low as only 7.6 F above zero, and contained only 0.58 grains of water per cu ft of air.



Although weather conditions just like those charted here occur infrequently, the many variations of temperature and moisture content of the atmosphere often make blast furnace air conditioning essential

Hydrogen Needed in Blast

Naturally the question arises, if moisture causes high coke consumption why not remove it all? The answer is that a certain amount of hydrogen in the blast is absolutely required for the best results in the working of the furnace. Sir Lowthian Bell recognized this phenomenon during his studies on hydrogen in the blast furnace (see section XI, Principles of the Manufacture of Iron and Steel, by I. Lowthian Bell, London, 1884). In discussing the presence of hydrogen he says, on p. 313, "So far, however, as the promotion of reduction is concerned, it is probably immaterial whether this gas deoxidizes the ore direct, or whether it decomposes carbonic acid with the liberation of carbonic oxide. In either case the presence of hydrogen must, it may be supposed, help to maintain the reducing energy of the gases. All my experiments tend to prove not only that this energy is intensified by the cooperation of hydrogen with carbonic oxide; but that a mixture of the two oxides of carbon (CO and CO_2) had its power of deoxidizing iron one increased by the presence of this third gas, perhaps beyond the point which might be expected from its relative volume."

A successful iron and steel executive once said that he would be willing to pay a blast furnace superintendent a good salary if he did nothing else but keep the right amount of limestone on the furnace. If he were living now, he probably would say the same thing about a man who could keep the right amount of moisture in the blast.

* * *

AND TO CONTINUE the subject of the proper moisture content of blast furnace air, and the reasons for conditioning such air, there are presented on the following pages an article upholding the "one grain or lower" viewpoint, by Gerald F. Mannion and Norman Weinstein, of the dry blast division of the Trane Co., and an article on three grain air for blast furnaces by L. L. Lewis, vice-president of the Carrier Corp. . . . Neither of the following two articles is a "discussion" of Mr. Sweetser's preceding article on the subject; the editors asked Messrs. Mannion and Weinstein, and Mr. Lewis, to prepare comment on the one grain and three grain air viewpoints, respectively, with the hope that in this way HPAC's readers would be more fully informed of why engineering opinion varies on a matter which is of great importance to industry both in wartime and in the days of peace to follow:

ONE GRAIN OR LOWER

By Gerald F. Mannion and Norman Weinstein
of the Dry Blast Division, The Trane Co.

ANY INDUSTRIAL engineer knows that easy control of quality is synonymous with greater production, and control of quality is simplified when the ingredients are of a known and stable analysis.

In modern blast furnace practice the ores, coke, scrap, and stone are carefully analyzed, proportioned, and controlled. Their analyses are known facts before they enter the furnace. But less attention has been given to the one ingredient which is greater by weight and by volume than all these solids combined—the blast, and its changeable moisture content.

Gradually the necessity for controlling the moisture content of the blast is being recognized as an essential part of good furnace operation, but there still remains one main point of controversy: How much moisture should be carried in the blast? There are almost indisputable facts in favor of reducing this moisture to a very low point, and up to this time we have located nothing but hypothetical theory to offset them.

The hot blast which is introduced at the tuyeres of the furnace accomplishes a threefold purpose: (1) It provides the oxygen necessary for combustion. (2) It controls the quality (silicon and sulphur) of the iron. (3) It provides heat units to assist the coke (carbon) which is fed into the top of the furnace.

Oxygen for Combustion

Each cubic foot of air contains a definite amount of free oxygen. That portion of each cubic foot of air which is inhabited by moisture contains roughly two parts hydrogen and one part oxygen. For the oxygen in this moisture to be freed for combustion purposes, it must be disassociated by means of heat in the presence of carbon. Therefore, any given volume of moisturefree air has greater combustion effect than a similar volume of air with a higher moisture content.

The Linde Air Products Handbook, as well as Johnson's Principle, Operation and Products of the Blast Furnace, state: "When the water content of air was reduced to 0.003 grains per 35,310 cu ft combustion was slowed up. At a temperature of minus 180 C combustion was slowed up. From minus 80 C to minus 50 C carbon burned. At minus 15 C to plus 5 C combustion was perfect."

Air at minus 15 C under atmospheric pressure will carry a maximum moisture of 0.53 grains per cubic foot.

From the above it would seem that one grain per cubic foot of air is well within the ideal range of combustion.

Beyond any question of a doubt, the effective heat at the hearth is greater with low moisture.

Control of Quality

In the control of quality (silicon and sulphur) almost any moisture level maintained at a given point is helpful, provided there is plenty of stove capacity to hold the blast heat at the desired point. However, it follows naturally that the blast which is most immediately effective will result in closer quality control.

In spite of the efforts made to feed the furnace a well balanced diet of solid materials (ore, coke, stone, scrap), it does not always move with the same regularity, and it is necessary to raise and lower blast heat levels as the analysis tends toward hot or cold iron.

If the blast contains a low percentage of moisture the effect on the heat of the iron should be more immediate. Fewer heat units are required for the disassociation of a lesser volume of moisture, and more heat can be used for the specific purpose for which it was intended.

Economy of Coke

Reduced to its simplest form, a blast furnace is a huge cylinder set in a vertical position. Ore, coke, stone, and scrap are fed into the top and air is blown in at the bottom. After proper reduction and fusion the primary product is molten iron.

This reduction and fusion can be accomplished only with heat energy, which is supplied by the coke and the preheated blast. The perfect balance between these two sources of heat has not yet been reached, but over the years it has come closer and closer to approaching its optimum.

Not so many generations have passed since the blast entered the furnace as natural air with no preheating. The air was introduced solely for combustion purposes. The man first to offer the idea of preheating the blast was considered slightly daffy. Today, no iron producer could long survive economically if he attempted to make his product with coke as the only source of heat.

From a tonnage production and coke saving standpoint the hearth has long been considered "the weakest point in the furnace." The effort to use higher stove heats year after year is in definite support of this truism. But stove structures, availability of gas, and the balancing out of the solids with the blast heat, represent a puzzling combination which varies with the changing characteristics of one or more mediums.

By controlling the moisture of the blast we are able to eliminate one of these variables and reduce the problem to a simpler form. By holding this moisture level at a low point we have added to the total effective stove heat, and can expect more immediate response to our "quality control."

If the effect of this heat is a known and more powerful factor, less heat need be held in reserve to overcome the variables created by changes in stock, or the rate of travel of that stock through the furnace.

To follow this reasoning we must continue to focus our attention on the hearth of the furnace, commonly called its weakest point. Only a portion of the work performed at the hearth is done by the hot blast. The more we can do with it the better, but to do it all is a physical impossibility with present-day heats and accepted furnace practice.

The remainder of the work done at the hearth is accomplished by the carbon (coke) which has descended with the stock. The unconsumed carbon is still a good proportion of that which was contained originally in the coke. Inasmuch as this share of the original coke has travelled a long way for the ultimate purpose of working at the hearth, it would seem that a definite portion of its energy would be dissipated before it arrived at its destination. Most certainly it would be better if as much hearth heat as possible could be applied directly at that point.

Now there is no attempt here to show that the coke (carbon) needed at the hearth comes down in a nice little bundle, and performs no good service enroute. We are simply stating that the extra coke required to allow for sufficient heat at the hearth should be lessened if we could substitute some additional heat units with a low moisture blast. It would seem that any work done by the heat units in the hot blast would relieve the coke (carbon) from an equal amount of work.

Of course, like any other form of energy, the heat of the blast cannot be utilized in its entirety for its prim-

ary function. So the residue heat continues up the stack, doing its share of reduction as it worms its way along.

If the effective heat of 1100 F, one grain blast is greater than that performed by 1100 F, three grain air, doesn't it follow that more coke will be saved?

Increased Production

If a low and uniform moisture is maintained in the blast, greater tonnage should be obtained for the following reasons: (1) The furnace should move more smoothly because a variable has been eliminated. (2) Ore can be substituted in the space previously required by our "saved" coke. The result is increased tonnage of the same quality, or the same tonnage of a higher quality.

Is Moisture Needed in Blast?

There are some people who advocate that the blast should contain a limited amount of moisture. The space allotted to this particular paper will not allow for a complete and thorough discussion of this point, so we shall have to be content with the following observations:

1) Few blast furnace analysts or operators feel that there is need for more hydrogen than that which enters with the stock at the top of the furnace.

2) Many combustion engineers assert that the blast would be even more effective if it contained less than one grain of moisture.

3) Any of the moisture which enters with the blast, and becomes entrained in the hot iron, must be worked out at the open hearth, or it will have a bad effect on the finished product.

4) One grain of moisture per cubic foot of air is far from "bone dry."

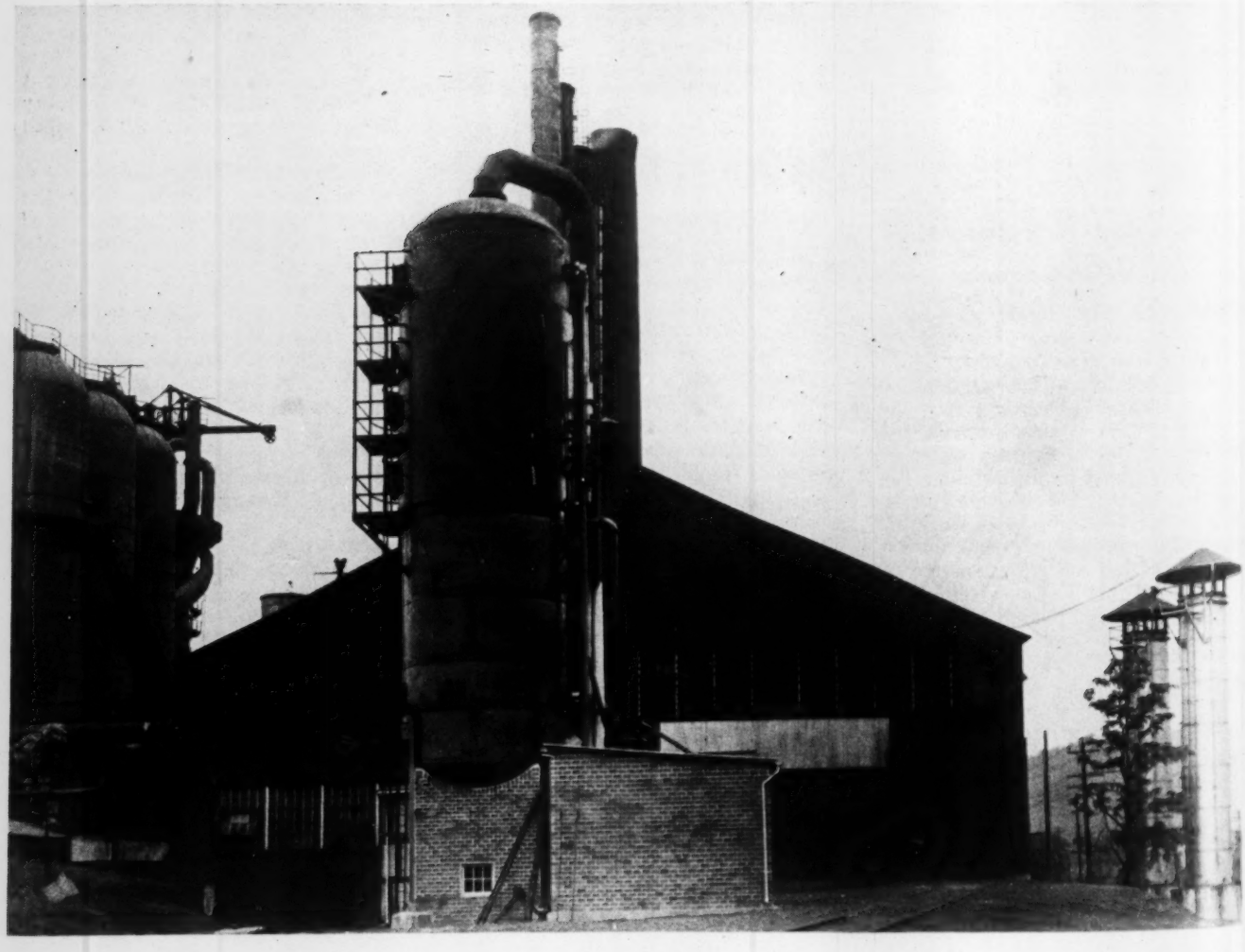
Because comparative tests at various degrees of controlled moisture have yet to be exhausted, we would hesitate to make a premature statement which would preclude the idea that no good could come from some moisture in the blast. But it would seem difficult to marshal very many positive, factual arguments to support its presence as being necessary.

It is most certainly true that one grain moisture delivery is no longer a serious mechanical problem. Systems are now installed and operating, and they are using less refrigeration horsepower than that previously needed for three grain operation. Any of these one grain systems can deliver two grain, three grain, or higher controlled moisture by the simple setting of a controller. But if a unit is designed for three grain delivery, it will not be of sufficient capacity for experimenting or operating at lower levels.

It is unfortunate that this moisture level controversy still rages, in view of the broad acceptance of the controlled moisture idea. Undoubtedly, a definite amount of good can be obtained from uniformity alone, and full advantage should be taken of this sound means of increasing our country's steel production. From the latest news drifting across the Atlantic and Pacific, we can use it in the nation's most immediate and pressing problem.

CONDITIONING EQUIPMENT FOR BLAST FURNACE

A "one grain" installation, an after compression job. Air enters the intakes at the right of the picture, goes to blowers in the large building, then is conditioned in the center tower, and continues on to the stoves at the left



WHY THREE GRAINS?

By L. L. Lewis, Vice-President, Carrier Corp.

WRITING THIS in the first person is distasteful for I have grown up as part of a team—but its logic is such that it would be quite inappropriate to express it in any other style.

The humility of its background is such that a clear understanding of it is essential. I, therefore, state with considered emphasis that I have no furnace operating experience whatsoever and that my knowledge of chemistry is hardly above kindergarten in relation to the complexity of the reactions that take place in a furnace.

Therefore, this must be written on the basis of experience with air conditioning systems and experience with proof of the principles which have been evolved during a lifelong experience in applying many types of air conditioning systems to a wide variety of industrial processes.

My practice with respect to furnaces has been that of listening with keen and absorbing attention at the feet of those whose practical operating experience and knowledge of chemistry I respected. It had its beginning under the tutelage of James Gayley. Teamed up with my life long associate, E. T. Murphy, I absorbed what the "father of dry blast" had to say about furnaces, but disagreed and argued with him—unsuccessfully—on the merits of "freezing the moisture out" of the wind versus removal in a "rain chamber."

Currently, I am duly impressed with one common link between the past and the present. Operators agree that there is nothing static in a furnace. They agree that it is sensitive to apparently insignificant changes and that such changes can lead to gross irregularities.

They admit with impressive frankness that not all that goes on in a furnace is known; that the only facts that can really be nailed down consist of what goes in as raw material and what comes out as product and by-product. They point with justifiable pride to their achievements in reducing and controlling practically every cause of irregularity but that of moisture content.

In general practice, they still apply various measures to combat uncontrolled variations in the wind. Outstanding among such measures are the readjustment of the speed of blowers to compensate for variations of density at the blower intakes, the readjustment of burden with relation to anticipated moisture level, and the readjustment of hot blast temperature to apply the final correction for sharp variations in moisture content.

During the years between Gayley and the present, I have gained a rich, practical "operating experience" in air conditioning. I have been the doctor who made the diagnosis and wrote the prescription, the druggist who filled it and, on occasions, the coroner who conducted the inquest.

If inexcusable errors are thrown out of the findings, these inquests can all be resolved by one common solvent. They have been the result of overdoing, of too much and too fancy automatic regulation, and of reaching for the moon.

Out of this kind of operating experience has developed the firm conviction that the law of diminishing returns applies universally—that at times the economic point could be determined accurately. But in all the cases there was proof that when requirements were carried to an extreme, the cost went up and the effect of variations above and below the base went down.

Hence, to me, the vital point is not one of level but one of regularity. Perhaps a little more could be gained by going to lower levels but there remains the question of how this will relate to the operation as a whole.

Many years ago, Gayley discovered with amazement and gratification that regularity in the blast increased production and made savings in fuel which greatly exceeded the theoretical prediction. But his hands were tied by his conviction that the only practical means of removing moisture was by "freezing it out" and, therefore, he had to design his plants for a level of two grains or less.

In 1939, Woodward Iron, in southern practice with foundry iron, again proved that the benefits of regularity could greatly exceed the theoretical. Their results were obtained with three grains. Somewhat later Jones & Laughlin—applying northern practice in steel making—found that the theoretical expectation was exceeded. Aliquippa achieved its results with three grains but found no impressive difference between regularity at three grains and regularity at four to four and a half grains.

To face the complete array of facts squarely and honestly, we must give due cognizance to the fact that other furnaces have failed to respond to the regularity of moisture content at levels ranging from four grains to one grain.

In the light of this array of facts, we must grant that the problem is perplexing and that it will not yield readily to theoretical solution. Also, that we must be tolerant in all cases.

Out of all of this has grown the conviction that regularity of grains will give results at any level if the burden is put on and provided the furnace will "take it."

As to level, I believe that the law of diminishing returns points to three grains. Adherence to it will hold invested capital and problems of operation to moderation—will give regularity by leveling the averages down to three grains and, if found desirable, will take out the valleys by leveling up to three grains.

Thorough consideration cannot avoid certain byproducts of this means of regularity because it has both a day by day value as well as a lasting one. If the wind is preconditioned by chilling before it enters the blower intakes, the need for varying blower speed to compensate for variations in air density will be eliminated. Concurrently, the amount of power required to blow the furnace will be reduced by an amount practically equal to that required for chilling.

Gayley observed this in his first experiences and wrote it into his records in frankly unconcealed surprise.

Increases in production and fuel savings currently stand alone in importance to our war effort, but long term and overall operating and maintenance economy will displace this first order in the peace that is to follow.

As a matter of principle which duly recognizes the value of furnace operating experience, I will make no attempt to predict that three grains are better than two or one or nothing. Likewise, I will make no claim that air conditioning at any grain level will enable the operator to increase the production of his furnace and save fuel.

Air conditioning is just an instrument which will provide one of the essential regularities by ironing out the variables in moisture level. It can give the operator that supreme confidence, which he must have if he is to drive his furnace, only when it is applied in that moderation and manner which will instill the requisite confidence. That is the matter of prime importance, not the exact grain level. Gains cannot be had unless the furnace can be and is driven accordingly.

[For further information about Mr. Lewis' viewpoint, see his paper Why Dry Blast Is Different Now, in Blast Furnace and Steel Plant for October, 1941, and Moisture Removal from Blast Furnace Air, presented at a conference sponsored by the ASRE and published in Refrigerating Engineering.]

Lead pipes from a house of ancient Rome

A HISTORY OF PIPING

M. A. Hasselmann Briefly Surveys Beginnings of Man's "Greatest Transportation System"

PIPING WAS probably one of the earliest inventions of man. It came after the hammer, spear, and bowl but before the wheel. It probably came right after the invention of the trough for, logically, the first form of piping was simply a covered ditch or trough, possibly carrying seepage water from the back of Mr. and Mrs. Neanderthal's cave through the living room and out the front door. Perhaps one day Mr. Neanderthal got tired of repairing his covered trench by the usual methods, and looked around for something better. He spied a hollow log in the ripples of the nearby creek with water running through it, said "That's it!" (or a reasonable facsimile), and brought it up. Thereafter, the area of his cave beside and above that hollow log was dry and habitable. Possibly he had already been using a hollow log as a convenient drinking fountain.

One thing is certain about the invention of piping: It happened many times, in different parts of the world, and at times separated by thousands of years. One would have difficulty arguing that the American Indian, who used piping to smoke dried wild tobacco leaves and to make arrow heads (by dropping water from a hollow reed to heated pieces of flint), learned about piping from the Tigris-Euphrates "cradle of civilization" on the opposite side of the world. Piping invented by cave men of a certain area a hundred thousand years ago might easily have been lost, say, to the nomadic tribes that succeeded them, and possibly to the agrarian race that succeeded the nomads, to be revived by the agrarian-urban race that followed. Reason: need. The agrarian-urban race needed trenches and piping to irrigate the land and make better use of it in order to feed the larger population, and to supply water to the cities.

That "necessity is the mother of invention" cannot be denied when you

realize that, usually if not always, inventions are incidental to a larger objective. In ancient times, during periods of success, security, and general contentment, the rulers and their relatively contented supporters and subjects built huge, durable-as-possible palaces, fountains, gardens, temples, forts, and monuments to express their feeling toward life and death and their feelings of importance, permanence, and power. The artisans who were assigned the building of these structures invented piping or piping improvements incidentally as a means to gain their larger ends. In the same way the inventors of the steam engine had to develop steam piping with valves inserted in order to control their engines. Today's artisans have had to develop stronger and more corrosion resistant, wear resistant, and vibration resistant pipe and pipe connections in order to achieve their larger ends—machines that require huge pressures, that operate continuously and for long periods, that process corrosive solutions, that must be built faster, etc.

So at the dawn of historical times we find piping pretty well known to artisans of the ancient civilizations, with each group making piping of the most suitable material it had at hand. Piping was in use in at least two parts of the world 5000 years ago.

Clay Pipe Lines

Embedded in cement in the floor of a low arched passage under the walls of a temple in Babylon are twin baked clay pipe lines that carried rain water from the roofs of the temple to cisterns beneath the courtyard of the domestics' quarters. A number of tees and bends show that the problems of turns had been solved. The cisterns likewise were skillfully built and water was drawn from them with a pail at the end of a rope, much in the manner of the "old oaken bucket." Trinkets and pottery, dropped by those who bent over the cisterns' openings, have been found at the bottom of the cisterns. The fact that this piping was used in a domestic convenience application indicates that it must have been in rather general use at that time.

Ten years ago a 15 ft square bathroom with tile drain pipes was uncovered in what is now Iraq. It was in the palace of a Babylonian king who reigned 4500 years ago, and is the earliest known bathroom.

Canals or channels—"uncovered piping"—were used throughout this area to conduct water from the rivers for irrigation purposes. The earliest known "pipe line" of this type was in ancient Assyria. Later these channels were lined with masonry and eventually the need for water justified cutting some through solid rock. In one case a canal 28 miles long was hewn through hardshell limestone, with the channel 44 ft deep in some places.

This ancient civilization lasted a long time. Still going strong at 700 to 600 B. C., its largest city, Nineveh, was supplied by water through open canals. Also, the records of the ancients tell us that Cyrus the Great, during his march on Babylon, terminated in 539 B. C., waited a year at one place for favorable weather and during that time built a water system.

By 500 to 400 B. C. the artisans of the Tigris-Euphrates valley had developed a means of attaching sections of piping together. Baked clay tubes found at Senjirli were made 12 in. long by 4½ in. in diameter, with a wall 4/5 in. thick. On one side was a rabbet, on the other a 2 in. cusp, or point. The cusps were thrust into the rabbets to prevent change of position. At the point of contact the pipe sections were joined tightly with clay.

Earliest Metal Piping

While the people of the predominantly flat, clay soiled, Tigris-Euphrates valley probably confined themselves to stone and clay piping (what metals they could put their hands on were used for jewelry, religious symbols, and tools of war) the Egyptians had enough copper that they could use some for piping in their most important edifices. Also, because their valley drainage system emptied into the Mediterranean and invited commerce thereon, they were more of a maritime people. Having ships they had access to the large copper deposits on the Island of Cyprus (the Roman pronounciation led to our word "copper.") Consequently, we find within the temple of Abusir, built over 5000 years ago, a brass or copper pipe line. It ran from the upper temple along a connecting masonry causeway to the outer temple, at the high water mark of the Nile. Apparently, the excavations do not show clearly whether the pipe inclined toward the inner temple and pyramid and supplied a royal swimming pool there or whether it inclined toward the river and was a drain. Both explanations are given. It might even have siphoned water up a small incline from the river.

This is the earliest known metal piping and was probably made by first casting into a thin layer or skelp, bending the skelp around a cylindrical form, and pounding the overlap into a weld. It is doubtful whether it was pounded into a sheet as such pounding would soon make copper brittle and the ancients probably had not discovered annealing for the purpose of removing such hardness. Besides, the melting and casting of copper and its tin alloy, bronze, and its zinc alloy, brass, were achievements begun by primitive man—ending the Stone Age and beginning the Bronze Age—and highly developed by the Egyptians (as revealed by their works, art, and inscriptions.)

The ancient Egyptians had a high regard for copper; their symbol for it was called the "Ankh" and is part of Tut-Ankh-Amen's name, which meant "enduring life." The Egyptians developed a pit type smelting furnace and the first forced draft, a valveless bellows with bamboo nozzle. On the bellows-flattening stroke, most of the air went into the furnace while some leaked back out through the intake opening. Each furnace had two bellows, one for each foot of the slave who operated them. As he stepped on one bellows and emptied it of air, he lifted the other and filled it. The Chinese later developed the first valves; the intake hole of a similar bellows was placed where the operator's heel covered and closed it on the down stroke.

Like their Tigris-Euphrates contemporaries, the early Egyptians had the potter's wheel with which they shaped their pottery and clay piping.

Magic Doors and Steam

The first inkling of the use of piping for conveying steam was revealed in the secret writings of the Egyptian priests several years B. C. Temple doors were operated by steam from a boiler in the altar. The priests quite mystified their followers by building a fire in the altar and predicting that shortly thereafter the temple doors would open without human assistance. The doors, of course, opened when the steam pressure became adequate and were closed by counterweights as the altar fire subsided.

Bamboo a Natural Piping Material

Just as nature aided the invention of piping by supplying trees which, for various reasons, decayed on the inside first or while the outside was still growing, nature also provided bamboo and hollow reeds. Bamboo was a natural piping material for the Chinese and they have used it extensively in this manner since antiquity. Centuries ago they made the first gas pipe lines of bamboo, piping gas to stoves for evaporating sea water to get salt.

One can assume that the Chinese had various applications of piping during their earliest recorded exis-

SUMMARY—You probably won't find any methods described here which you will want to put to use tomorrow—although, with wartime shortages and restrictions on materials, some of the techniques of the ancients might solve a piping problem of today at that . . . In this article—the first of a group on the history of piping scheduled for publication in HPAC—Mr. Hasselmann, of Tube Turns, Inc., reviews the development of our "greatest transportation system"—piping—through the ages . . . It's interesting reading, so take a few minutes from today's job to see how the piping engineers of other days solved their problems.

tence although nothing that their ancient contemporaries in the Mediterranean basin and adjoining areas did not also have. Unfortunately, where the eastern Asiatics did invent some things ahead of their western contemporaries (e. g., a superior vertical smelting furnace with feeding tray, a bellows with valves, gunpowder), these developments were not made available to western contemporaries, who had to invent them again later. Consequently, none of our piping developments can be said to come from Chinese or other eastern Asiatic sources.

Terra Cotta Pipes

In 2000 B. C. there flourished on the island of Crete, many populous cities. In one of these the great king Minos erected an amazing palace, the remains of which indicate luxury, refinement, and conveniences unmatched by any preceding or contemporary civilization.

The domestic wing of this palace was at least three stories high and water was supplied all stories through terra cotta pipes. The pipes were tapered so as to give the water a shooting motion, intending to prevent the accumulation of sediment and facilitating the fitting of one section into the other. The waste line, large enough for a man to pass through, was ventilated by air shafts accessible through manholes.

Two latrines on the upper floor were provided with small wooden seats. A semi-circular hole in the floor led to a small duct toward which the floor sloped. This was for flushing purposes. A curious projection in the toilet drain is believed to have mounted a balanced flap which shut off sewer gases. The modern vented toilet follows this installation in principle. By 1500 B.C., this city had complete municipal water supply, sewage, and drainage systems.

During excavations in this area shortly after the turn of this century, a small "stop-and-get-a-drink-and-wash-your-feet-and-rest" shelter was discovered. After removing gypsum deposits from the pipe that led from the nearby spring, water bubbled forth and filled the foot basins just as it had done 4000 years before!

King Solomon's Water System

The reservoirs and aqueducts built in the reign of King Solomon are considered as great as any technical achievement of antiquity. Their construction indicates a definite knowledge of the laws of water pressure. This water system served a double purpose—water for people and animals, and water for irrigation. The aqueduct that carried water from the hills to the palace was actually a tunnel or pipe with air shafts to prevent air pockets and to release odors. Today a mosque stands on the site of the temple and uses the original aqueduct.

As ancient Jerusalem was naturally deficient in water supply, a tunnel, nearly a third of a mile long was cut through a rocky hill to a pool just outside the city but within bow shot of the wall. This engineering feat, completed in 727 B. C., was begun simultaneously at both ends, as revealed by an inscription near its mouth and by a 3 ft jog in the tunnel.

The inscription tells in detail how, lacking proper instruments, the workmen failed to meet although they could hear each other's picks hitting the rock. Throughout the greater part of the work, the workmen must have labored on their hands and knees, or even lying flat, and, possibly, with tools no harder than bronze. The water of such ancient city systems was delivered to public fountains, not to homes.

Nebuchadnezzar's Hanging Gardens

To please his queen, who had been reared in a distant, hilly land, and longed for the scenes of her beloved youth, Nebuchadnezzar built the so-called Hanging Gardens, the term being a misnomer, having arisen from a faulty translation of the Hebrew for "supported."

This colossal structure was reared terrace upon terrace. Each terrace had lawns with a profusion of flowers and fruit trees. Inside were superbly decorated, fragrant, vaulted chambers.

Three wells supplied water which was lifted by a system of chain pumps to a reservoir lake on this world's first "roof garden." The water cascaded down over the terraces, irrigating the vegetation and cooling the chambers below. The problem of protecting this priceless structure from damaging leaks was met in much the same manner as is done today: Troughs and channels were lined with nonferrous metals such as lead and bronze.

Greek and Roman Aqueducts

The Greeks used the best of other ancients' ideas and added much to them—piping included. The best-known achievements of the ancient water works engineers were the aqueducts leading into the Greek and Roman cities, both from their size and their present state of preservation.

The Greeks thought that good water should be conveniently available to all. Their water systems branched off to fountains in every neighborhood and to individual homes in many streets. The Greeks realized that good water and health went hand in hand and enacted rigid laws to regulate water use. It was a serious crime to pollute drinking water or to wash clothes in it. Fountains were guarded at all times.

The Greeks used the tunnel almost exclusively for their main lines or aqueducts, largely to conceal them from siege-bent enemies who otherwise could cut off or poison the city's water supply. The water usually flowed through such tunnels in clay pipes, although channels in the rock floor were also used. Occasionally a line of pierced stones cemented together (stone pipe) would be used.

A brilliant engineering feat was an 8 ft square tunnel 4200 ft long, constructed 535 to 522 B. C. at Samos. A high rocky ridge rimmed the city and this tunnel, still open, penetrated it to springs on the opposite side. Syracuse's tunnel, built that same century from the island city under the narrow, shallow harbor to the mainland, is in use today.

The baked clay pipe used within the Greek cities to distribute water was usually square with rounded corners, and every other section was pierced for ventilation. This piping was often laid along the curb of the street, protected by a covering of small stones and tile plates. In their distributing system the Greeks also used large quantities of wood pipe (drilled logs) and lead pipe.

The First Iron Makers

A wrought iron blade was found in the base of one of the pyramids of Egypt, erected 3000 B. C., and a wrought iron sickle blade was found beneath the base of a sphinx near Thebes, also erected long before the Greeks. However, the Greeks are credited with the development of iron for commercial use. References in both the Old and the New Testament tell how iron was first taboo with the ancients east of the Mediterranean, then deified and, by the time of Christ, was as common as brass. A biblical reference, Genesis 4:22, speaks of Tubal-cain as "an instructor of every artificer in brass and iron."

If the Greeks had enough iron to use some for piping they probably could not get it hot or malleable enough to work into such a complicated shape as a tube. They had no furnace that could heat iron until it flowed and could be cast. The ancients were confined to working wrought iron—getting a mass red hot and pounding it to remove impurities and to form desired shapes. Unless their work has rusted away no one ever thought of making pipe of iron until 2000 years later, after the invention of gunpowder in Europe, when iron barrels for small firearms were first made.

SCRAP HITLER!

BUY

WAR BONDS

Heating-Piping-Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

R. B. Stanger

Semi-Annual Meeting at Pittsburgh

C. M. Humphreys

THE PITTSBURGH Chapter has sent members of the Society a cordial invitation to come to the Semi-Annual Meeting 1943 to be held at the William Penn Hotel, June 7-8. It will have a streamlined program with all sessions devoted to technical activities.

The Council and the Committee on Research plan to meet in advance of general sessions.

Registration of members will commence on Monday, June 7. The first session will be called to order by Pres. M. F. Blankin at 9:30 a. m. In general, the subjects selected by the Meetings Committee for discussion will be of special interest to engineers engaged in war work. Other subjects definitely cover phases of engineering research which will be of value in the postwar period.

The general chairman on arrangements, Ralph B. Stanger, has organized the chapter committees to serve during the meeting and the work of the hospitality committee will be under the direction of F. C. McIntosh. The customary entertainment features are being omitted and, except for entertainment of the ladies who will attend, the only important social function will be the Semi-Annual Dinner at which the presentation of the Past President's Emblem and the Past President's Memory Book will be made to Prof. E. O. Eastwood, Seattle.

The meeting schedule provides for technical sessions on Monday and Tuesday, and also a panel discussion.

For those who are interested in attending this meeting the committee urges that early hotel reservations be made and that transportation arrangements be completed well in advance. It is also suggested that round trip transportation be secured.

Pittsburgh offers many advantages as a meeting place during these busy times. It is near the geographical center of membership, and therefore will enable a maximum number to attend the meeting with a minimum of traveling. It is easily reached by railroad from any direction. Pittsburgh hotels are not overcrowded and are prepared to offer excellent and ample accommodations.

The Pittsburgh members say, "as long as hospitality and good fellowship are still unrationed, we promise to do our best to supply the hospitality, and if each of you will bring a fair share of good fellowship, the lack of the higher priority items will not be noticeable."

Plan for Pittsburgh June 7 and 8.

General Chairman, Ralph B. Stanger; *Vice-Chairman*, Clark M. Humphreys.

Hospitality Committee: F. C. McIntosh, *Chairman*, T. M. Dugan, John L. McCullough, Robert A. Miller, H. Lee Moore, Arthur F. Nass, Bertram B. Reilly, G. L. Simpson.

Entertainment Committee: Harold E. Park, *Chairman*, H. A. Beighel, Van A. Reed, Jr., Chas. H. Schneider, R. H. Sweeney.

Banquet Committee: Edward C. Smyers, *Chairman*, Glen Moore Comstock, Horton J. Kirkendall, Albert W. Marshall, Paul C. Strauch.

Ladies' Committee: Mrs. Theo. F. Rockwell, *Chairman*, Mrs. John F. Collins, Jr., Mrs. Clark M. Humphreys, Mrs. David W. Loucks, Mrs. L. S. Maehling, Mrs. F. C. McIntosh, Mrs. Robert A. Miller, Mrs. H. Lee Moore, Mrs. Arthur F. Nass, Mrs. Bertram B. Reilly, Mrs. Edward C. Smyers, Mrs. Paul C. Strauch, Mrs. G. G. Waters.

Publicity Committee: David W. Loucks, *Chairman*, John F. Collins, Jr., Paul A. Edwards, Albert F. Metzger.

Finance Committee: L. S. Maehling, Edward H. Reismeyer, Jr., Theo. F. Rockwell.

The Historic Point

Here at the confluence of the Allegheny and Monongahela, where starts the mighty Ohio on its trek south, is the apex of the famous *golden triangle*. Rich in historic interest and the location of the original Fort Duquesne, there still stands the Block House which is all that remains of this early defensive structure. From the Point, on a perfect triangle, stretch the buildings and businesses of Pittsburgh.

Preliminary Program

SEMI-ANNUAL MEETING

William Penn Hotel - June 6-7-8, 1943 - Pittsburgh, Pa.

Sunday, June 6

1:00 p. m. Registration—(Silver Room)

1:30 p. m. Council Meeting—(Forum Room)

7:30 p. m. Committee on Research—(Parlors E and F)

Monday, June 7

9:00 a. m. Registration—(Silver Room)

9:30 a. m. TECHNICAL SESSION—(Urban Room)
Reports of Officers
Amendments to By-Laws
Performance of a Residential Panel Heating System, by H. F. Randolph and J. B. Wallace
Operation of a Heating Plant Using Sun Energy and Radiant Heating, by W. C. Knopf, Jr.

2:00 p. m. TECHNICAL SESSION—(Urban Room)
Final Values of the Interaction Constant for Moist Air, by John A. Goff, J. R. Andersen and S. Gratch.
Study of Actual vs. Predicted Cooling Load on an Air Conditioning System, by J. N. Livermore
Spray Nozzle Performance in a Cooling Tower, by L. M. K. Boelter and S. Hori

3:00 p. m. Ladies Tea

5:00 p. m. Chapter Delegates Conference

7:30 p. m. Committee Meetings

8:00 p. m. Nominating Committee Meeting

Tuesday, June 8

9:30 a. m. TECHNICAL SESSION—(Urban Room)
Heat Transmission Through Insulation as Affected by Orientation of Wall, by F. B. Rowley
Graphical Method of Calculating Heat Losses, by P. D. Close
Use of the Down Draft Coking Principles for Smokeless Combustion, by J. R. Fellows and John C. Miles
Field Study of Comfort Reactions of Apartment Dwellers Under Fuel Oil Rationing, by Sallye Hamilton

11:00 a. m. Ladies Breakfast—Bridge

2:00 p. m. TECHNICAL SESSION—(Urban Room)
The Economic Factors of Converting Recirculated Air for Ventilation, by H. E. Ziel and Henry Sleik
Panel Discussion: Will Current Ventilating System Operation Undermine Public Health and Efficiency?

7:00 p. m. Dinner—(Urban Room)
Presentations: Past President's Emblem and Memory Book to Prof. E. O. Eastwood

Method of Choosing Location of, Financing and Conducting Meetings of the Society

Resolved: That inasmuch as the Annual and Semi-Annual Meetings of the Society come under the jurisdiction of the Council, the following rules governing the handling of such meetings be adopted by the Council and published in the JOURNAL of the Society at least twice during every year, preferably just prior to each meeting.

1—The Council will select the city in which the Annual or Semi-Annual Meeting is to be held, giving due consideration to the invitations received from Chapters or members as well as to the advisability of so distributing those meetings as to make them of the greatest advantage to the general membership, and to reduce as far as possible the expense of members attending.

2—That an appropriation be made to cover the entertainment or local expenses, incurred in connection with the meeting not exceeding $500.00, the regular meeting expense to be taken care of by the General Fund of the Society in the regular way.

3—That no registration fee or compulsory obligations of any nature be imposed on members or guests.

4—That the purchase of tickets for banquets or for any other form of entertainment that may be provided be entirely voluntary.

5—That the grouping of features and the sale of tickets for group features be discouraged.

6—That the raising of funds from manufacturers of heating apparatus be discouraged.

7—That the display of samples, or of literature, advertising the product of any manufacturer in any way, shape or form, be not permitted at the booths, registration desk, or in or about the meetings.

8—That the distribution of trade papers be entirely at the discretion of the committee in charge.

9—That the local Chapter or local members be empowered to form a General Committee with such sub-committees as may be required to handle the details of transportation, hotel accommodations, entertainment, finance, etc., and that this General Committee be requested to confer frequently with the Council, through the Secretary of the Society, and to make frequent reports on progress in connection with the various matters being handled by them.

10—That the arrangements of elaborate and costly entertainment features be discouraged.

Adopted at Council Meeting, January 29, 1926.

Spray Nozzle Performance In a Cooling Tower

By L. M. K. Boelter* and S. Hori,** Berkeley, Calif.

This paper is the second of a series on spray tower performance. The research program is sponsored by the American Society of Heating and Ventilating Engineers in cooperation with the University of California.

SUMMARY—This paper, which is the second in a series dealing with spray tower performance, presents the results of tests in which the quantity of water supplied to the tower was varied by changing the nozzle pressure and by changing the number of nozzles. Results are also given for tests which show the beneficial effect of placing screen plates and screens below the nozzles. Two types of nozzles were used.

Introduction

THE PERFORMANCE of a spray tower depends on the amount of water in the tower at a given time, the degree of dispersion of the water into drops and/or sheets and the velocity of the individual liquid particles. In a previous paper (1) experimental results are reported in which the liquid rate was changed by increasing the pressure on a fixed number of nozzles. This procedure increased the number of drops, decreased their size, increased their initial velocity and changed their trajectory as the nozzle pressure was augmented. In this paper the results of tests are reported in which the liquid rate in a tower of given dimensions was increased both by increasing the nozzle pressure and also by increasing the number of nozzles.

The effect of tower length (equivalent to tower volume for a given cross-section) on the energy transfer from the water to the air was evaluated experimentally for a given number of nozzles of one type. In addition two widely different types of nozzles were compared and finally the effect of two screen plates placed below the nozzles was studied and two wire meshes were compared.

The data and results of the tests are presented without the support of analytical treatment. The writers hope that this information will be part of a body of information which will eventually yield satisfactorily to a generalized algebraic analysis.

Description of the Apparatus

The tower employed for these runs has been described in a previous paper (1). A photograph and a vertical section are included as Figs. 1 and 2 respectively. For these runs the contra-flow side only was employed. The tower was thoroughly insulated so that the heat transfer to the surroundings was negligible.

The nozzles shown in Figs. 3A and 3B which were used to obtain the experimental data presented herein are classified as hollow-cone nozzles (2). Fundamentally, the water enters a whirl chamber (Fig. 3A) or through a fixed curved passage (Fig. 3B) and acquires a rapid rotation. The fluid on exit forms a hollow conical sheet and then breaks up into drops. This type of nozzle, as its name implies, gives a cone shaped spray with the large fraction of the water spraying outwards, away from the center. Although this distribution of the water is undesirable in most cases, much smaller drops result from a hollow-cone nozzle than a solid-cone nozzle of the same capacity (1). The experimental technique utilized was similar to that employed by the earlier investigators who used this tower.

Unit Volume Enthalpy Conductance

The results are presented here on the basis of the unit volume enthalpy conductance the concept of which was presented in a previous paper (3). Consideration was given to the range of operation for which the concept is applicable (4). Although practically all data on mass transfer systems are presented on the basis of the unit volume mass conductance, the results are presented here on the basis of the unit volume enthalpy conductance since the cooling towers are essentially energy exchangers and the actual performance is rated on the amount of cooling obtained. Also, the conductance was computed on the basis of the heat sensibly removed from the water, $L_1 \Delta T$, where L_1 is the water rate on to the tower and ΔT is the decrease in temperature of the water, instead of the energy gained by the air in passing through the tower. The performance curves are to be used primarily in the design of cooling towers. The energy increase of the air is practically equal to $L_1 \Delta T$ and the latter will be utilized in this paper.

This unit volume enthalpy conductance is then defined as

$$f_h a = \frac{L_1 \Delta T}{V\ (\Delta h)_{lm}} \qquad \text{(1a)}$$

where $f_h a$, the unit volume enthalpy conductance is the rate of sensible energy transfer per unit of spray volume for a unit of enthalpy potential. This conductance is based on a concept similar to that employed in correlating the performance of spray ponds (5). Its more correct definition for the cases in which the logarithmic mean is applicable (6) is

$$G\ (h_1 - h_2) = (f_h a)\ V\ (\Delta h)_{lm} \qquad \text{(1b)}$$

The unit volume enthalpy conductance established for this tower is made up of two contributions, (*a*)

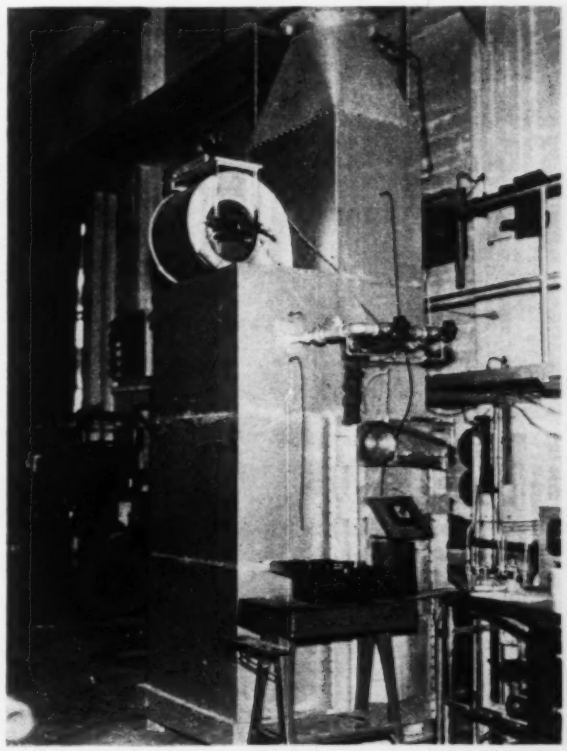


Fig. 1—View of spray cooling tower showing thermocouples, potentiometer, and air measuring devices

*Professor of Mechanical Engineering, University of California.

**Teaching Assistant, Dept. Mechanical Engineering, University of California.

Numerals in parentheses refer to bibliography.

For presentation at the semi-annual meeting of the American Society of Heating and Ventilating Engineers, Pittsburgh, Pa., June, 1943.

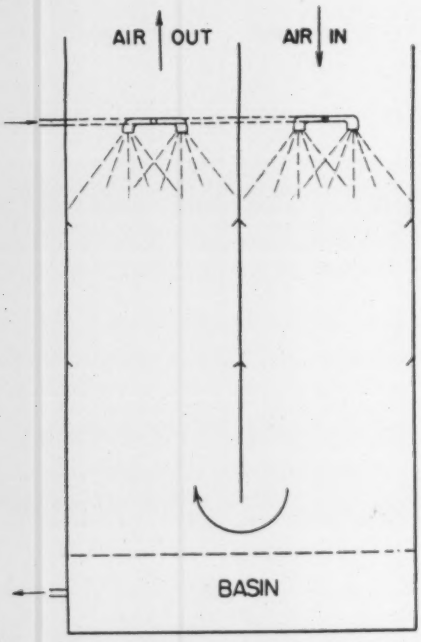


Fig. 2—Flow diagram of spray cooling tower, 4 ft x 3 ft x 7 ft

due to the drops, (*b*) due to the liquid sheet flowing down the tower walls. Roughly these unit conductances are additive for the systems operate in parallel. The sheet cooling apparently contributes about one-fourth of the total unit conductance (1). In the Discussion of Results no attempt is made to separate the wall (liquid sheet) contribution from the total cooling. Generalization of these results in a tower of a different cross-section, employing similar nozzles can be accomplished by utilizing the liquid rate per unit cross-sectional area of the tower (L_l/S) and calculating the corresponding unit volume conductances. This procedure will not yield the correct result because of the contribution of the wall sheets to enthalpy transfer (*i.e.*, cooling), but it is proposed as a working approximation.

Discussion of the Results

Effect of Number of Nozzles in Tower: The tests of the first series were performed to investigate the over-all performance of the spray cooling towers using various numbers of spray nozzles in the spray chamber as shown in Fig. 4. Fig. 3A illustrates the nozzles employed in the spray chamber for these runs. This group of runs was performed with a constant inlet water temperature, constant tower volume, constant gas rate and varying water rates. The data and results are tabulated in Table 1. Fig. 5 presents a series of curves showing the isothermal discharge rates of the nozzles as a function of the pressure at the nozzle and the number of nozzles. From the parabolic shape of the curves, it is evident that the discharge rates of the nozzles are nearly proportional to the square root of the pressure difference, as stated by H. G. Houghton (2).

In Fig. 6 are presented the results of the first series of tests. Here, the unit volume enthalpy conductance is plotted as a function of the pressure at the nozzles with the number of nozzles in the spray chamber as the parameter. A series of constant water rate (nozzle discharge) lines are also plotted. From this graph, the effect of the number of nozzles and the pressure at the nozzles for a given water rate is evident. For a given water rate, a comparatively slight increase in conductance is obtained by reducing the number of nozzles, while a large increase in nozzle pressure is required to maintain the same water rate. This effect is more noticeable at the lower water rates. These results may be explained by a consideration of the performance of the nozzles under the various conditions.

It is known that for pressure nozzles, the average drop size is approximately inversely proportional to the

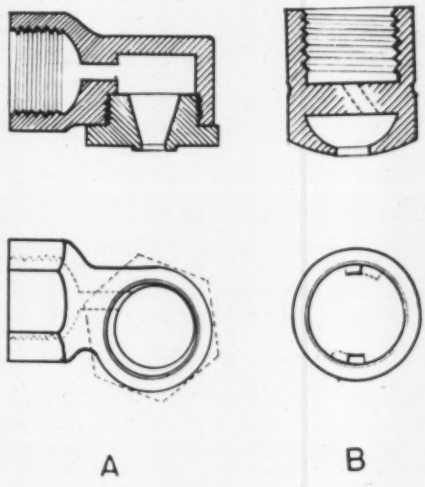


Fig. 3—Cross-sections of typical hollow-cone pressure spray nozzles

(*A*) Diameter of pipe connection: ⅜ in.
Diameter of discharge orifice: 7/32 in.
(*B*) Diameter of pipe connection: ¼ in.
Diameter of discharge orifice: 3/16 in.

square root of the pressure difference, that is, inversely proportional to the liquid rates for a given liquid (2). Therefore, for a given water rate and type of nozzle, as the number of nozzles is increased, the required pressure is reduced, thus producing larger drops. Also, the greater the number of nozzles in a given tower volume, the greater the chance of interference between the various sprays. At the higher pressures, the drops will approach a limiting size which will depend on the type of nozzle and the dynamical conditions in the tower. This effect will partially account for the flattening of the curves at the higher pressures. It is also due to the fact that a limiting discharge rate will be approached as the pressure difference across the nozzles is increased over a wide range.

The equations noted in Fig. 5 reveal that the exponent of the liquid rate term decreases with an increase in the number of nozzles. This means that the increase in the conductance is less for a given increase in the liquid rate for a large number of nozzles, as contrasted with a few. The result can be partially explained by the fact that the effect of interference between the various sprays is increased in the case of the greater number of nozzles and the greater quantity of water within the spray chamber at any given time will decrease the magnitude of the driving potential.

Fig. 7 is a cross-plot of Fig. 6 and reveals the unit volume enthalpy conductance as a function of the number of nozzles for various pressures at the nozzles. Constant water or tower rate lines are also shown on this plot. It would be expected that if there were no interference between the sprays, the unit volume enthalpy conductance would increase linearly with the number of nozzles. This effect is clearly seen by considering the experimental points shown on the graph. For the 30 and 20 lb per square inch pressures at the nozzles, the first three points corresponding to 1, 2, and 3 nozzles, lie nearly along a straight line and the curve gradually deviates further away from a line drawn through these points. The decrease in slope is due to the interference between the various sprays. At a pressure of 10 lb per square inch gauge, the first four points lie approximately along a straight line. Again, the result may be attributed to the fact that there is less interfer-

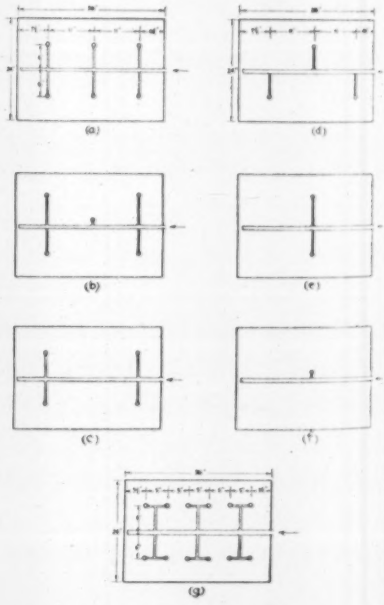


Fig. 4—Cross-section of spray chamber showing positions of nozzles for tests using various numbers of nozzles

1 in. nominal size main pipe
(*a*) to (*f*) Nozzles *A* ⅜ in. nominal size pipe arms
(*g*) Nozzles *B* ¼ in. nominal size pipe arms

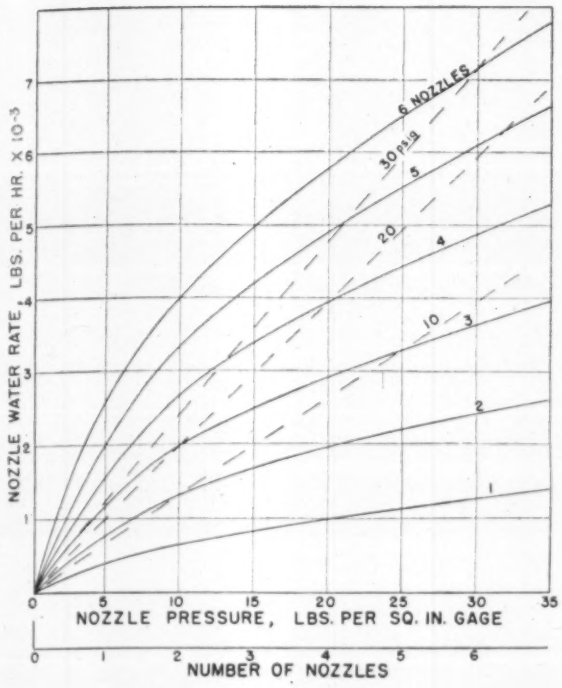


Fig. 5—Discharge characteristics of the nozzles (A)

Legend:
——— Nozzle pressure as abscissa
- - - - Number of nozzles as abscissa
$L_1 = 181\ NP^{0.536}$ expresses the results for water temperature $T = 90$ F

ence at the low pressure due to the smaller cone angle of the spray. From a consideration of the constant water lines, it can be stated that the relative cooling advantage of using less nozzles and a higher pressure is greater at the higher water rates.

Effect of Length of Spray Chamber: Another series of runs was made to investigate the effect of the length of the tower on the over-all performance of the system. These runs were made with the type A nozzles at three different heights in the spray chamber (Fig. 8) while maintaining the inlet water temperature and gas rate approximately constant and varying the water rate to the nozzles.

The results in this case were presented on the basis of the total volume enthalpy conductance which is expressed by

$$(f_h a V) = \frac{L_1 \Delta T}{(\Delta h)_{lm}} \quad \ldots\ldots\ldots (1c)$$

where $(f_h a V)$ is the rate of transfer of sensible heat for the total chamber volume per unit of enthalpy potential. This conductance is used so that the relative performances can be compared in terms of values independent of the actual tower volume.

This series of test results are shown in Fig. 9 (also Table 2) where the total volume enthalpy conductances are plotted as a function of the tower volume for various pressures at the nozzles. The curves indicate that the total volume enthalpy conductance approaches a limit as the tower length is increased, if the operating conditions are maintained invariable. The lower the nozzle pressure or water rate, the more quickly the limit is approached. Beyond an optimum tower length it would be uneconomical to further increase the length of the tower to obtain the correspondingly slight increase in the conductance. This rapid approach to a maximum conductance substantiates the conclusion (1) that the greater portion of the cooling in the tower takes place near the entrance of the water into the tower. Therefore, at the lower pressures, since the cone angle is small, a large portion of the water travels down the center of the tower

Table 1—Tabulation of Data and Results for Tests Using Various Numbers of Nozzles *A*

Run No.	Number of Nozzles	Pressure at Nozzles	Nozzle Discharge Rate	Water Conditions			Psychrometric Properties of Air							Mass Balance			Energy Balance			Log Mean Enthalpy Potential	Unit Volume Enthalpy Conductance
				Inlet Temp.	Outlet Temp.	Sensible Heat Loss	Rate	Inlet Air			Outlet Air			Water Vapor gained by Air	Measured Rate of Evaporation	Diff.	Energy Gained by Air	Total Energy loss by Water	Diff.		
								Dry bulb Temp.	Wet bulb Temp.	Relative Humidity	Dry bulb Temp.	Wet bulb Temp.	Relative Humidity								
	N	P	L_1	T_1	T_2	$L_1\Delta T$	G	t_{1DB}	t_{1WB}	R_1	t_{2DB}	t_{2WB}	R_2	G Δ H	Δ L	D_L	G Δ h	$L_1\Delta T + \Delta L h_L$	D_h	$(\Delta h)_{lm}$	$f_h a$
		psig	lbs. per hr.	°F	°F	Btu per lb	lbs. per hr.	°F	°F	%	°F	°F	%	lbs. per hr.	lbs. per hr.	%	Btu per hr.	Btu per hr.	%	Btu per lb d.a.	Btu per hr. ft³ (Btu/a)
17c	6	35	7700	90.2	80.1	77,800	4570	66.4	60.8	72.9	79.0	79.0	100	52.5	60.8	-12.63	71,400	81,420	-13.30	15.15	146.7
18c		30	7150	90.0	79.1	77,900	4560	65.5	58.1	63.9	77.0	77.0		52.3	61.2	-14.61	70,000	80,780	-8.89	16.53	134.5
20c		25	6460	90.1	77.3	82,700	4560	63.4	51.1	41.3	74.1	74.1		52.4	66.1	-10.12	77,100	85,700	-10.02	19.22	122.9
19c		20	5780	90.1	78.3	68,150	4540	66.2	57.5	58.5	74.7	74.7		47.5	54.4	-12.69	61,900	70,870	-13.26	17.37	112.1
21c		15	4960	90.1	76.4	67,500	4650	65.9	52.5	39.0	71.6	71.6		52.8	56.8	-7.04	64,100	74,020	-8.45	19.65	98.1
22c		10	3965	90.0	75.9	56,000	4710	68.0	53.9	38.2	71.3	69.9	93.2	45.9	48.6	-5.55	54,000	58,140	-7.11	19.31	82.9
23c		5	2535	90.0	74.8	38,500	4650	69.8	54.0	33.6	70.7	68.3	76.5	33.0	36.2	-8.84	39,200	40,010	-2.02	19.94	55.1
14c	5	30	6080	90.7	79.9	65,600	4600	67.3	61.9	73.6	77.7	77.7	100	45.85	50.9	-9.92	61,900	68,040	-9.02	15.05	112.9
15c		20	4920	90.9	79.3	53,100	4590	67.7	62.3	73.9	76.5	76.5		41.24	45.6	-9.45	50,350	59,260	-15.03	15.49	105.3
16c		10	3365	90.6	78.1	42,100	4570	69.2	62.5	68.7	73.7	73.7		33.39	41.4	-19.30	41,450	44,010	-5.81	16.26	74.0
10c	4	30	4870	91.8	79.2	61,400	4450	72.7	61.9	53.9	77.5	77.5	100	42.15	54.3	-9.44	59,100	63,980	-7.76	16.19	108.3
11c		30	4920	90.8	78.6	60,000	4690	68.3	62.4	72.0	76.8	76.8		41.40	45.9	-9.80	54,900	62,140	-11.48	15.4	111.3
12c		20	3960	90.9	78.4	49,500	4530	68.7	63.4	74.5	75.7	75.7		36.10	38.4	-5.99	47,750	51,280	-6.88	15.4	91.9
13c		10	2677	90.7	77.3	35,820	4590	69.2	63.0	70.9	72.6	72.6		29.28	29.8	-1.68	37,000	37,140	-0.46	16.0	64.0
4c	3	30	3635	90.2	75.8	52,300	4800	70.5	60.1	54.1	72.9	72.9	100	42.0	45.15	-6.97	49,100	54,280	-9.55	16.09	93.0
5c		20	2918	90.0	75.5	42,500	4710	70.0	60.1	57.4	71.9	71.3	97.1	35.05	36.05	-2.77	41,100	44,070	-6.74	16.21	74.9
6c		10	1991	90.2	77.4	25,500	4580	76.8	66.0	56.1	75.4	72.6	87.4	24.77	25.6	-3.24	25,470	29,680	-4.46	14.50	50.3
1c	2	30	2422	90.7	75.4	37,150	4690	72.4	62.0	55.3	72.7	71.5	94.4	32.0	35.0	-8.56	35,370	38,760	-8.53	15.69	67.9
2c		20	1951	90.2	75.8	27,900	4690	74.7	64.0	56.3	72.8	70.6	85.1	25.0	29.5	-6.34	24,950	29,190	-4.88	15.92	52.1
3c		10	1309	89.8	72.5	22,610	4730	72.8	58.8	42.4	70.7	66.3	79.4	25.8	24.0	+4.9	25,800	23,580	+4.96	16.62	38.8
7c	1	30	1267	91.3	73.7	22,300	4660	75.2	63.7	52.7	72.2	69.7	88.1	23.5	25.2	-6.64	22,220	23,350	-4.84	14.69	43.4
8c		20	987	89.9	73.1	16,590	4640	75.1	62.5	48.7	71.9	67.9	81.5	21.08	21.0	+0.33	19,490	17,450	+11.69	14.99	31.6
9c		10	651	90.2	72.8	14,330	4610	75.5	62.9	48.9	73.3	67.3	73.2	17.39	16.0	+8.55	14,670	11,990	+22.36	14.60	22.2

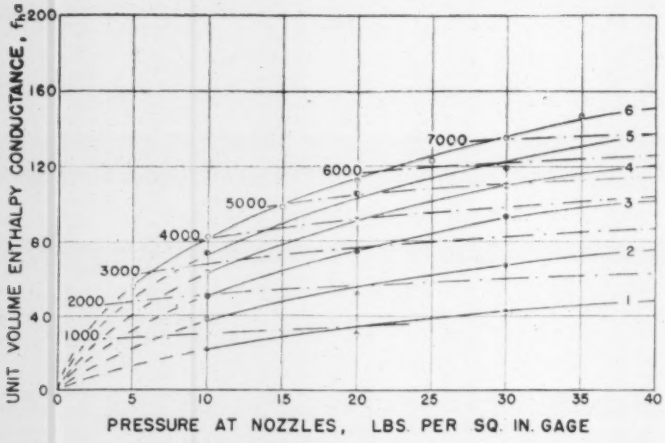


Fig. 6—Unit volume enthalpy conductance *vs.* pressure at nozzles for various numbers of nozzles in spray chamber

Operating Conditions:
Inlet water temp. = 90 F.
Air rate = 4600 lb of dry air per hour
Nozzles (A)
Tower volume = 35 ft³
Legend:
——— Fixed number of nozzles
– – Constant water rate at nozzles, lb per hour

Unit volume enthalpy conductance as a function of water rate on the tower for 1 to 6 nozzles:

$$(f_h a)_1 = 0.0288\ L_1^{1.03}$$
$$(f_h a)_2 = 0.0244\ L_1^{1.02}$$
$$(f_h a)_3 = 0.0342\ L_1^{0.965}$$
$$(f_h a)_4 = 0.0476\ L_1^{0.914}$$
$$(f_h a)_5 = 0.0716\ L_1^{0.836}$$
$$(f_h a)_6 = 0.096\ L_1^{0.816}$$

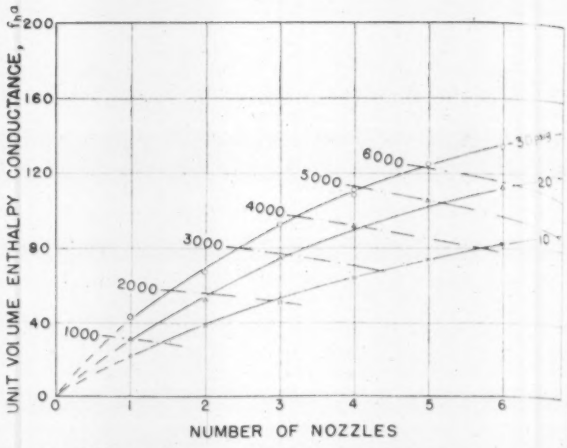


Fig. 7—Unit volume enthalpy conductance *vs.* number of nozzles for various pressures at nozzles

Operating Conditions:
Inlet Water Temperature = 90 F.
Air rate = 4600 lb of dry air per hour
Nozzles (A)
Tower volume = 35 ft³
Legend:
——— Constant Pressure at Nozzles, psig
– · – Constant Nozzle Water Rate, lb per hour

and is cooled rapidly and quickly approaches the practical limit to which the water can be cooled. Measurements by H. F. Johnstone and R. V. Kleinschmidt (8) designed to determine absorption coefficients in spray towers also indicated that the rate of absorption was high immediately in front of the nozzles and that it dropped off rapidly with distance.

The rapid cooling of the drops near the nozzles may be attributed to the high velocities of the drops on discharging from the orifice and the high potential at the liquid entrance end of the tower. The high velocities tend to decrease the resistance to mass transfer on the gaseous side of the liquid-gas interface, thus resulting in high rates of evaporation and heat transfer. Due to the small mass of the drops and the resistance of the counterflowing air, the drops are quickly decelerated to their limiting velocity (9) and slowly drift downward.

The total volume enthalpy conductances as a function of the pressure at the nozzles for the three volumes considered are plotted in Fig. 10. A comparison of the values of the exponent of the empirical equations noted on the figure demonstrates that within the normal operating range, the rate of increase of the total volume enthalpy conductance with liquid rate is higher for a larger tower volume than for a smaller tower. This result may be due to the fact that for the short lengths of tower, the period of contact between the drops and the air was decreased so much that the beneficial effect of the increased transfer area at the higher pressures is partially counteracted by a further decrease in the time of contact due to the increased velocity of the drops. An optimum time of contact between the drops and the air exists for which the most effective cooling can be obtained in a tower of given length. If the tower is shortened to decrease this period of contact to such an extent that the drops are not allowed sufficient time to cool, the tower would be impractical.

The curves shown in Fig. 11 are the unit volume enthalpy conductance plotted as a function of the tower volume for various pressures at the nozzles. The value of the exponent in the equations noted below Fig. 9 compare favorably with the results obtained by A. W. Hixson and C. E. Scott for the variation of the over-all absorption coefficients, $K_g a$, for ammonia and sulfur dioxide by liquid water and benzene vapor by straw oil. For a constant liquid rate and gas rate, the absorption coefficient for all three cases was found to vary approximately with the —0.5 (average of a series of experimental curves) power of the lower length.

The relationships obtained by Hixson and Scott were:

$$K_g a = \frac{C \cdot G^{0.8} \cdot L}{H^{0.5}}$$

(Ammonia by water)

$$= \frac{C' \cdot G^{0.8} \cdot L^{0.9}}{H^{0.5}}$$

(Sulfur dioxide by water)

$$= \frac{C'' \cdot G^{0.8} \cdot L^{0.9}}{H^{0.5}}$$

(Benzene vapor by straw oil)

Within the range of operation of the tower the unit volume mass conductance ($K_g a$) and the unit volume enthalpy conductance ($f_h a$), differ little (4). Therefore, it is justifiable to compare the various relationships

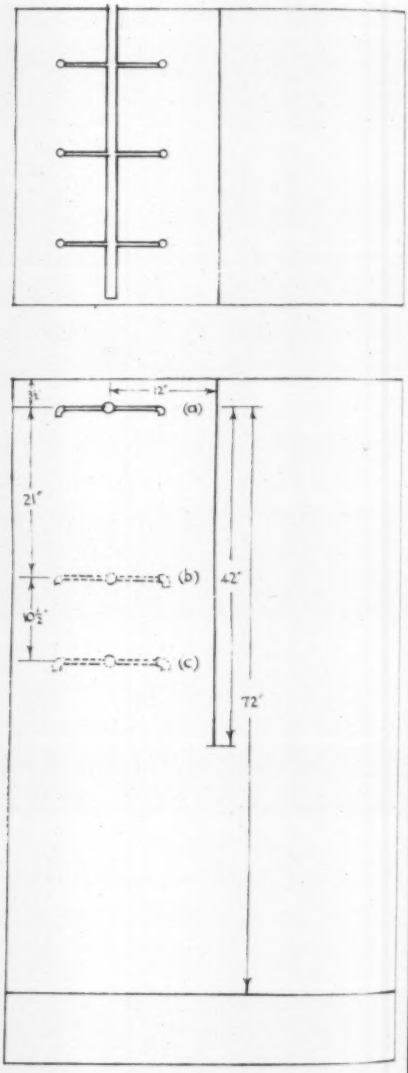


Fig. 8—Elevation section of spray chamber showing elevations of spray nozzles above tower outlet

Legend:
(*a*) Tower volume = 35 cu ft
(*b*) Tower volume = 24.5 cu ft
(*c*) Tower volume = 19.3 cu ft

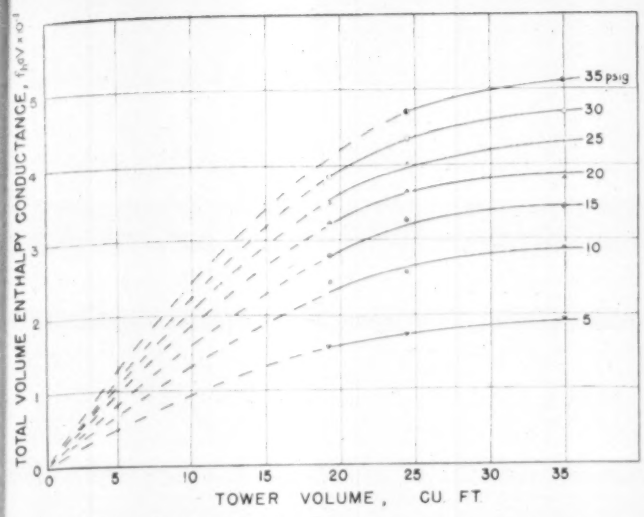


Fig. 9—Total volume enthalpy conductance *vs.* tower volume for various pressures at nozzles

Operating Conditions:
Inlet water temp. = 90 F
Air rate = 4600 lb of dry air per hour
Six nozzles *Type A*

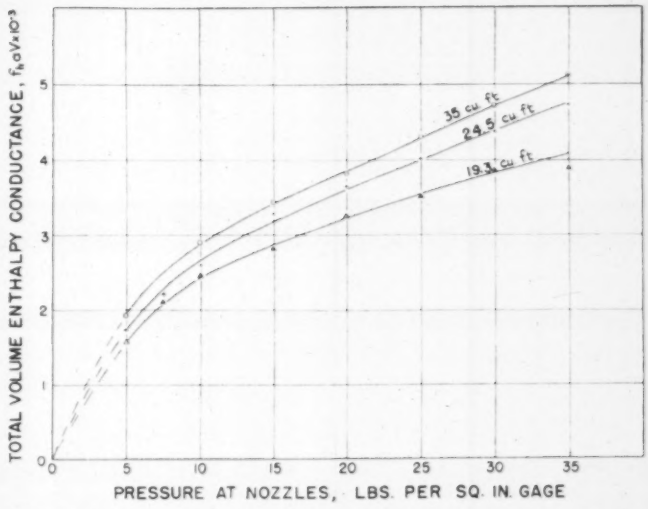


Fig. 10—Total volume enthalpy conductance *vs.* pressure at nozzles for various tower volumes

Operating Conditions:
Inlet water temp. = 90 F
Air rate = 4600 lb of dry air per hour
Six nozzles, *Type A*
Corresponding equations in terms of liquid rate:

$(f_h aV)_{V=35} = 3.36L^{0.816}$
$(f_h aV)_{V=24.5} = 3.88L^{0.79}$
$(f_h aV)_{V=19.3} = 4.83L^{0.75}$

obtained for $f_h a$ with the expressions of $K_g a$ of other investigators (10, 12, 13) when the mass transfer systems are similar. In all the systems being considered, the liquid side resistance at the liquid-gas interface is almost negligible as compared to the gas side resistance.

The values obtained for the exponent of the liquid rate ranged from 0.816 to 1.03 which compare very well with the mean values of 1.0 and 0.9 obtained by Hixson and Scott.

Effect of Type of Nozzle: Fig. 12 is a plot of the unit volume enthalpy conductance as a function of the water rate for the various numbers of nozzles of *Type A*, and also a curve obtained with 12 nozzles of *Type B* (see Fig. 3*B*) placed in the same spray chamber (Fig. 4*g*). This set of curves clearly shows the greater unit volume enthalpy conductance for the nozzles which generate the smaller drops. The statements of H. G. Houghton (2) that if a maximum number of small drops is required, nozzles of the smallest size practicable should be used and operated at the highest possible pressure are substantiated. The pressure differences required for *Type B* nozzles range from 10 to 47.5 lb per square inch gauge for a water discharge rate from 835 to 2000 lb per hour.

Effect of Screen Packings in Spray Chamber: From the conclusion that most of the cooling takes place near the nozzles, it seemed reasonable to presume that an increase in the unit volume enthalpy conductance could be obtained by placing wire mesh screen packing within the spray chamber perpendicular to the direction of the spray with the first screen far enough away from the nozzles to allow the fine drops to cool before striking the screen. After striking the screen, the lower portion of the tower would behave as a packed tower. The drops on leaving the nozzle, cool rapidly at first and soon approach a limiting temperature. Due to the thermal resistance within the drops, a temperature gradient is established along the diameters with the center of drops being the hottest. When the drops strike the screen, mixing among the drops occurs and new but larger drops are formed on the underside of the screen and fall by gravity to the next screen where the drops are again mixed. This mixing of the water and forming of new drops presents a surface of higher temperature to the surrounding air, thus increasing the rate of enthalpy transfer. Also, the time of contact between the water and air is lengthened. From a practical point of view, the introduction of the

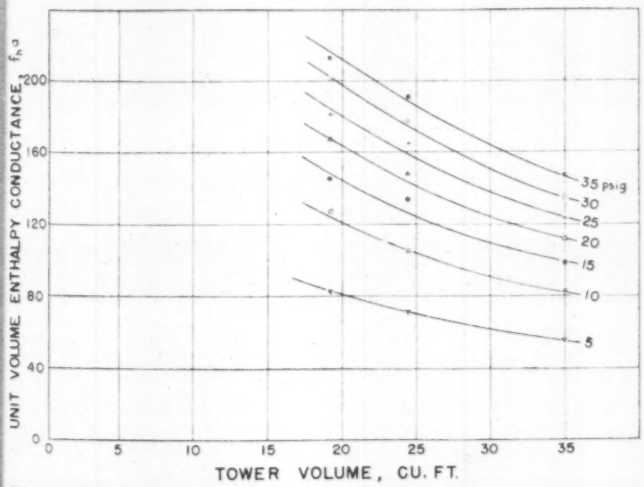


Fig. 11—Unit volume enthalpy conductance *vs.* tower volume for various pressures at nozzles

Operating Conditions:
Inlet water temp. = 90 F
Air rate = 4600 lb of dry air per hour
Six nozzles *Type A*
The corresponding equations for three nozzle pressures:

$(f_h a)_{35} = 1557V^{-0.69}$
$(f_h a)_{30} = 1245V^{-0.68}$
$(f_h a)_{10} = 919V^{-0.68}$

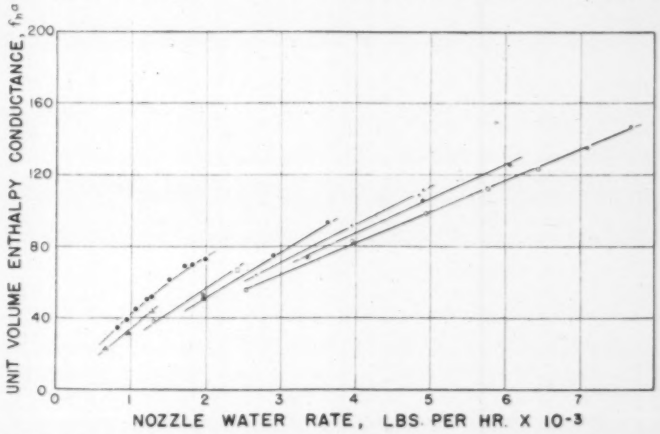


Fig. 12—Unit volume enthalpy conductance *vs.* nozzle water rate for various numbers of nozzles in the spray chamber

Legend:
12 nozzles *Type B*
6 nozzles *Type A*
Inlet water temperature = 90 F
Dry air rate = 4600 lb per hour

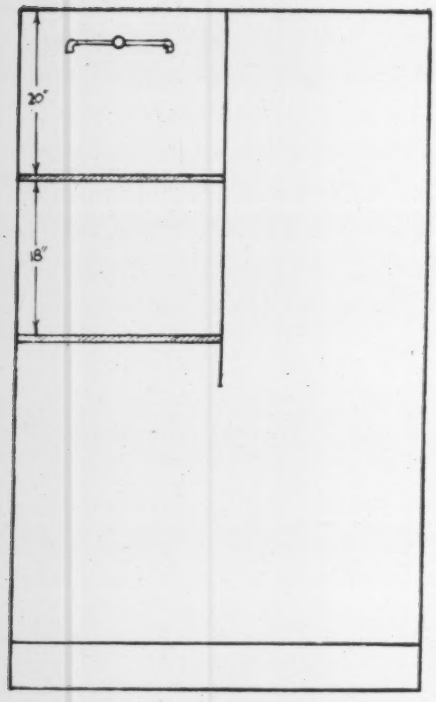


Fig. 13—Elevation section of spray chamber showing the positions of the screen packings in the tower

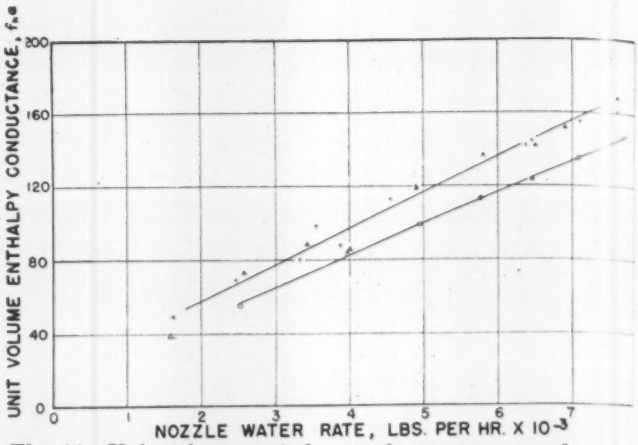


Fig. 14—Unit volume enthalpy conductance *vs.* nozzle water rate for spray chamber and screen packed chamber

Inlet water temperature = 90 F
Dry air rate = 4600 lb per hour
Six nozzles, *Type A*
Legend:
2 No. 4 mesh screens 2 No. 8 mesh screens

screens into the air stream will require more power to maintain the same rate.

To determine the actual effect of screen packings within the spray chamber, a series of runs was made with two sections of packing and with screens of two different meshes (10). The inlet water temperature and gas rate were maintained approximately constant during the runs while the water rate was varied. The test data and results are presented in Table 4. Although the experimental points are scattered somewhat, the results are conclusive. The scattering is probably due to the fact that the data for these curves were taken during shorter runs and that various interfering factors within the laboratory made it difficult to maintain steady state conditions during the runs.

The conductance, $f_h a$, is plotted as a function of water rate in Fig. 14. The percentage increase in the enthalpy conductance ranges from 23 to 16 per cent for nozzle discharge rates from 3000 to 7000 lb per hour. Unfortunately, the power input to the fan was not measured during these series of tests so that the increase in cost due to the higher pressure drop in the tower could not be determined.

From the results of these tests, it is evident that the addition of the screen packings to the system improves the performance of the unit considerably but there is no apparent difference in performance by the use of the two finer mesh screens. The spray nozzles serve to form small drops to obtain the benefits of spray cooling and also distribute the water across the tower section. The screen packings allow the droplets to intermingle and form surface sheets and larger drops as the water passes down the tower.

General Conclusions

A number of previous investigations have been made with respect to spray scrubbers or absorbers (8, 10, 12, 13) and correlations between analytical and experimental work have been partially established. Despite the similarity of the phenomena taking place within spray scrubbers and spray coolers (evaporative coolers), comparatively little work has been done in the latter field. Further investigations, experimental and analytical, will be required before a more complete correlation can be developed. The ultimate goal of these investigations is to establish a generalized basis for the correlation of the performance characteristics of the various types of transfer systems. It is visualized that these results, together with the results previously obtained on other types of cooling towers (3, 15, 16) will be of future use for the classification of cooling towers on a generalized basis.

In conjunction with the experimental work on actual cooling towers, investigations have been made to more fully understand the microscopic phenomena of the various processes taking place within the towers (4, 9). As yet, it is difficult to attempt to obtain a good correlation between the two approaches due to the wide gap existing between the ideal and actual systems.

The following specific conclusions aid to summarize this work:

1. Within the operating range of the pressure spray nozzle *Type A* (Fig. 1 *a*), the discharge rate varies with 0.56 power of the pressure difference across the nozzles.
2. For the various conditions investigated, the unit volume enthalpy conductance varies approximately with the square root of the pressure at the nozzles or directly with the water rate.
3. For a constant nozzle discharge rate, constant gas rate, constant length of tower and inlet water temperature, only a slight increase in conductance can be obtained for a relatively high increase in nozzle pressure by decreasing the number of nozzles.
4. The greater portion of the cooling takes place near the nozzles so that beyond a certain length of a spray cooling tower, very little increase in the conductance is obtained by further lengthening the tower.
5. For a constant gas rate, inlet water temperature, and pressure at the nozzles, the unit volume enthalpy conductance varies approximately with the -0.7 power of the tower length.
6. Although higher pressures are required, a higher conductance can be obtained by the use of a large number of small nozzles for a given water rate and tower volume. The limiting drop size depends on the gas velocity and must be such that no drift will occur (14).
7. A more effective tower results by the combination of the spray and screen packed types of cooling towers into a single unit.

Acknowledgments

The writers wish to acknowledge the suggestions and assistance of Messrs. A. R. Collins, J. T. Gier and H. H. Niederman. Appreciation is expressed to Messrs. H. Eagles, M. Evans and N. W. Snyder for their able assistance in the mechanical and experimental work. The information on spray nozzles made available by H. D. Bruce is also appreciated.

The cooperation of the Los Angeles and Golden Gate Chapters of the American Society of Heating and Ventilating Engineers, and the San Francisco Air Conditioning Society allows the continuation of this work. The tower and a set of spray nozzles were gifts of the W. R. Ames Co., San Francisco.

Nomenclature

a = enthalpy transfer area per unit of spray volume, square feet per cubic feet of volume.

$f_a a$ = unit volume mass conductance, pounds per (hour) (cubic feet) (pound per pound).

f_h = enthalpy transfer conductance, Btu per (hour) (square feet) (Btu per pound).

$f_h a$ = unit volume enthalpy conductance, Btu per (hour) (cubic feet) (Btu per pound).

$f_h aV$ = total volume unit conductance, Btu per (hour) (cubic feet).

G = gas rate (dry air rate) through tower, pound per hour.

h = enthalpy above the appropriate datum, Btu per pound.

Δh_{lm} = logarithmic mean enthalpy potential, Btu per pound of dry air

$$= \frac{(h_{T1} - h_1) - (h_{T2} - h_2)}{\log_e \left\{ \frac{h_{T1} - h_1}{h_{T2} - h_2} \right\}}$$

h_T = enthalpy of saturated air at mixed mean liquid temperature T Btu per pound dry air.

h_{L2} = enthalpy of liquid (water) at outlet temperature.

L = liquid rate, pounds per hour.

L_n = nozzle water rate (water on tower) pounds per hour.

ΔL = water evaporated into air stream measured as the difference of water on and off the tower, pounds per hour.

H = absolute humidity gain, pounds per pound dry air.

ΔH = difference of absolute air humidity at exit and entrance pounds per pound dry air.

N = number of nozzles.

P = pressure at the nozzles, also the difference in pressure across the nozzle the tower pressure being substantially atmospheric, psig.

R = relative humidity of air, per cent.

S = tower cross sectional area, ft.^{2}

t = air temperature, degree Fahrenheit.

T = water temperature, degree Fahrenheit.

ΔT = decrease in water temperature through tower, degree Fahrenheit.

V = spray volume (the volume of the tower), cubic feet.

Subscripts:

1 = conditions at water entrance section.
2 = conditions at water exit section.
lm = logarithmic mean.
DB = dry-bulb.
WB = wet-bulb.
da = dry air.
L = liquid (water).
log_e = logarithm to the Naperian base.

Properties of air-water vapor mixtures were obtained from the 1943 Edition of the Heating, Ventilating, Air Conditioning Guide.

Bibliography

1. Niederman, H. H., Howe, E. D., Longwell, J. P., Seban, R. A., and Boelter, L. M. K., Performance Characteristics of a Forced Draft, Counterflow Spray Cooling Tower, ASHVE Transactions, Vol. 47, 1941.
2. Perry, J. H., Chemical Engineers Handbook, Chap. 16, McGraw-Hill Book Co., 1941.
3. London, A. L., Mason, W. E., Boelter, L. M. K., ASME Transactions, Jan. 1940.
4. London, A. L., Nottage, H. B., Boelter, L. M. K., Ind. Eng. Chem., Vol. 33, 1941.
5. Hori, S., Patchett, U. A., Boelter, L. M. K., ASHVE Journal Sec-

Table 2—Tabulation of Data and Results Obtained for Various Heights of the Spray Chamber

Run No	Pressure at Nozzles	Nozzle Discharge Rate	Water Conditions			Psychrometric Properties of Air							Mass Balance			Energy Balance			Log Mean Enthalpy Potential	Unit Volume Enthalpy Conductance	Total Volume Enthalpy Conductance
			Inlet Temp	Outlet Temp	Sensible Heat Loss	Rate	Inlet Air: Dry Bulb Temp	Inlet Air: Wet-bulb Temp	Inlet Air: Relative Humidity	Outlet Air: Dry-bulb Temp	Outlet Air: Wet-bulb Temp	Outlet Air: Relative Humidity	Water Vapor gained by Air	Measured Rate of Evaporation	Diff.	Energy gained by air	Total Energy Loss by water	Diff.			
	P	L_1	T_1	T_2	$L_1\Delta T$	G	t_{1DB}	t_{1WB}	R_1	t_{2DB}	t_{2WB}	R_2	$G\Delta H$	ΔL	D_L	$G\Delta h$	$L_2\Delta T_2 \Delta h_L$	D_h	$(\Delta h)_{lm}$	$f_h a$	$f_h aV$
	psig	lbs. per hr.	°F	°F	Btu per lb.	lbs. d.a. per hr.	°F	°F	%	°F	°F	%	lbs. per hr.	lbs. per hr.	%	Btu. per hr.	Btu per hr.	%	Btu per lb. d.a.	Btu. per ft.^{3} per (Btu/lb.)	Btu per hr. (Btu/lb.)
TOWER VOLUME = 35 cu. ft.																					
17c	35	7700	90.2	80.1	77,800	4570	66.4	60.8	72.3	72.0	72.0	100	52.5	60.8	-12.63	71,400	81,420	-12.30	15.15	146.7	5130
18c	30	7150	90.0	79.1	77,000	4560	65.5	58.1	63.9	71.0	71.0		52.3	61.2	-14.61	70,000	80,780	-8.89	16.33	134.5	4700
20c	25	6460	90.1	77.3	82,700	4560	63.4	51.1	41.3	74.1	74.1		59.4	66.1	-10.12	71,100	85,700	-10.02	19.22	122.9	4300
19c	20	5780	90.1	78.3	68,150	4540	66.2	57.5	58.5	74.7	74.7		47.5	54.4	-12.69	61,300	70,670	-13.26	17.37	112.1	3820
21c	15	4960	90.1	76.4	67,500	4050	65.9	52.5	39.0	71.6	71.6		52.8	56.8	-7.04	64,100	70,020	-8.45	19.35	98.1	3437
22c	10	3965	90.0	75.9	58,000	4710	68.0	53.9	38.2	71.3	69.9	93.2	45.9	48.6	-5.55	54,000	58,140	-7.11	19.31	82.9	2900
23c	5	2535	90.9	74.8	38,500	4650	69.8	54.0	33.6	70.7	66.3	76.5	33.0	36.2	-8.84	39,200	40,000	-2.02	19.94	55.1	1930
TOWER VOLUME = 24.5 cu. ft.																					
1e	35	7660	90.0	80.1	75,700	4500	69.2	59.5	56.1	72.7	72.7	100	53.7	62.4	-13.93	68,200	78,700	-13.31	16.09	192.0	4710
2e	30	7110	90.1	79.7	74,000	4530	70.2	58.3	48.2	76.8	76.8		55.5	61.5	-9.76	68,100	76,940	-11.50	16.97	178.0	4360
3e	25	6460	90.0	79.4	68,500	4510	71.3	58.3	44.9	75.7	75.7		53.1	59.5	-10.76	63,000	71,260	-11.59	16.98	164.8	4030
4e	20	5800	90.0	79.3	62,050	4500	73.9	59.5	41.6	74.9	74.9		50.3	54.9	-8.39	58,000	64,610	-13.31	17.08	148.2	3640
5e	15	5040	90.0	78.5	58,000	4540	68.3	58.3	54.5	73.2	73.2		43.1	48.5	-11.12	52,550	60,260	-12.80	17.69	134.0	3280
6e	10	4075	90.0	78.6	49,500	4490	72.6	59.2	44.3	73.3	71.6	92.3	38.9	43.3	-10.17	42,760	48,520	-15.85	18.03	105.1	2579
7e	7.5	3540	90.0	78.2	41,750	4560	72.2	58.4	42.5	72.5	70.1	88.7	36.4	45.9	-20.7	40,000	43,870	-8.83	18.92	90.0	2204
8e	5	2740	90.0	74.4	42,740	4560	57.4	45.2	36.0	62.6	60.3	87.5	31.9	35.6	-10.4	40,400	44,250	-8.70	24.59	71.0	1740
9e	3	1770	90.0	78.1	24,600	4480	61.2	46.1	27.5	62.8	58.2	69.3	21.5	22.5	-4.26	25080	25,500	-1.99	26.40	38.0	932
TOWER VOLUME = 19.3 cu. ft.																					
1f	35	7690	90.0	82.1	60,700	4490	73.0	64.0	60.9	78.7	78.7	100	47.8	47.3	+1.05	58,600	63,070	-7.09	15.63	221.0	3880
2f	30	7160	90.1	81.3	63,050	4580	71.6	61.9	57.8	77.1	77.1		48.2	55.2	-12.65	58,900	65,770	-10.6	16.31	200.2	3860
3f	25	6520	90.0	81.6	54,800	4510	73.6	63.7	57.8	77.3	77.3		44.9	46.3	-3.02	53,300	57,100	-6.65	15.63	181.5	3500
4f	20	5840	90.0	81.9	47,300	4510	75.3	66.6	63.1	77.6	77.6		38.1	41.5	-8.2	44,600	49,370	-9.67	14.60	167.9	3240
5f	15	5095	90.0	81.9	41,250	4450	77.0	67.4	60.5	77.4	77.0		34.8	37.6	-7.98	38,600	43,130	-10.5	14.69	145.7	2810
6f	10	4120	90.0	77.5	51,500	4520	60.8	53.5	61.8	68.6	68.6		36.1	40.9	-11.73	47,900	53,360	-10.23	20.92	127.6	2460
7f	7.5	3560	90.0	77.7	43,800	4500	63.0	54.9	60.3	68.5	68.0	97.5	32.0	36.0	-11.11	41,700	45,450	-8.25	20.70	109.6	2118
8f	5	2800	90.0	78.9	31,100	4500	69.9	59.2	52.6	70.7	68.4	89.0	27.4	25.8	+6.2	30,900	32,310	-4.37	19.51	82.6	1592

Table 3—Tabulation of Data and Results of Tests Using Nozzles *B*

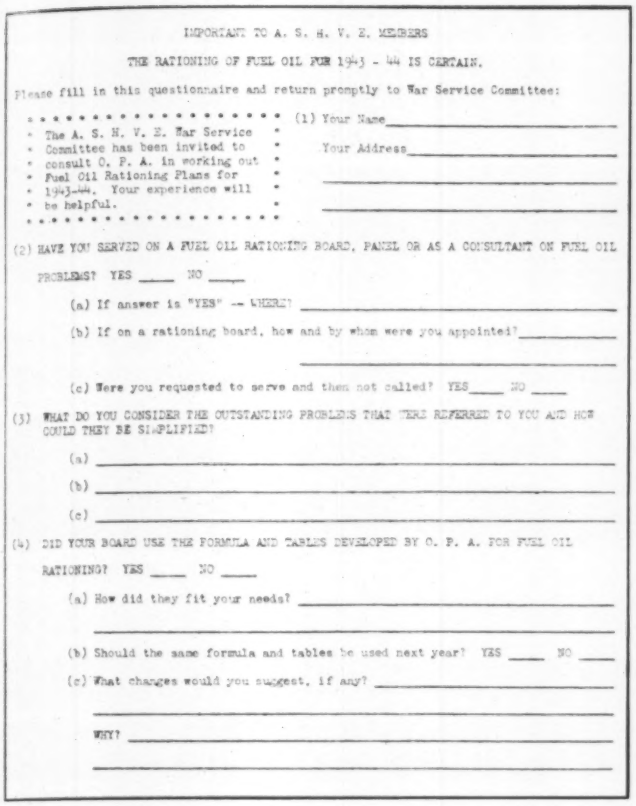
Run No	Pressure at Nozzles	Nozzle Discharge Rate	Water Conditions			Psychrometric Properties of Air							Mass Balance			Energy Balance			Log Mean Enthalpy Potential	Unit Volume Enthalpy Coefficient
			Inlet Temp.	Outlet Temp.	Sensible Heat Loss	Rate	Inlet Air			Outlet Air			Water vapor gained by Air	Measured Rate of Evap.	Diff.	Energy gained by air	Total Energy Loss by Water	Diff.		
							Dry-bulb Temp.	Wet-bulb Temp.	Relative Humidity	Dry-bulb Temp.	Wet-bulb Temp.	Relative Humidity								
	P	L_1	T_1	T_2	$L_1\Delta T$	G	t_{2DB}	t_{2WB}	R_2	t_{1DB}	t_{1WB}	R_1	$G\Delta H$	ΔL	D_L	$G\Delta h$	$L_2T_2h_2 - L_1T_1h_1$	D_h	$(\Delta h)_m$	$k_y a$
	psig	lbs. per hr.	°F	°F	Btu per lb	lbs. d.a. per hr.	°F	°F	%	°F	°F	%	lbs. per hr.	lbs. per hr.	%	Btu per hr.	Btu per hr.	%	Btu per lb d.a.	Btu per hr./lb d.a./°F
1b	47.5	2000	89.8	70.9	37,800	4550	71.2	58.3	45.3	69.6	69.6	100	36.6	42.0	-12.85	38,300	39,430	-2.95	14.87	72.6
2b	39.8	1840	91.5	70.7	38,220	4490	73.0	58.5	40.0	69.9	69.6	98.4	37.7	37.7	0	37,220	39,680	-6.15	15.60	70.0
3b	35.0	1727	91.8	70.0	37,600	4600	68.5	58.4	54.1	69.2	69.2	100	33.2	35.0	-5.15	37,100	38,930	-4.70	15.45	69.5
4b	26.9	1520	89.8	70.1	30,000	4550	71.0	59.7	50.9	69.6	68.5	94.6	29.1	30.85	-5.66	30,100	31,180	-3.46	14.10	60.8
7b	22.0	1290	90.7	68.6	28,530	4490	70.8	58.7	40.0	68.5	67.1	93.1	33.3	33.3	0	33,900	29,750	+3.97	15.49	51.8
5b	18.0	1223	91.6	69.8	26,850	4600	71.0	57.9	44.1	69.1	66.4	93.1	32.2	29.0	+7.65	29,650	27,950	+5.63	15.31	50.1
8b	14.8	1052	90.6	68.0	23,800	4460	72.2	56.6	36.2	68.9	66.9	90.5	33.6	29.85	+12.2	33,150	24,875	+33.3	15.13	44.9
6b	12.0	961	90.5	68.6	21,050	4550	67.9	57.2	51.2	67.6	64.3	83.4	20.8	22.4	-7.15	22,400	21,870	+2.42	15.86	39.0
9b	10.0	835	90.5	68.8	15,110	4380	73.5	57.7	36.8	70.7	67.6	85.3	31.7	22.4	+41.5	31,600	19,935	+58.9	14.84	34.6

tion, Heating, Piping & Air Conditioning, Vol. 14, October, 1942.

6. Heating, Ventilating, Air Conditioning Guide, 1943 Edition, Chapter 1, p. 10; Chapter 26, p. 549.
7. Hori, S., Performance of Spray Nozzles in a Water Spray Cooling Tower, on file Library, University of California, Berkeley, Calif.
8. Johnstone, H. F., Kleinschmidt, R. V., Trans. Am. Inst. Chem. Eng., Vol. 34, 1938.
9. Nottage, H. B., Boelter, L. M. K., Dynamic and Thermal Behavior of Water Drops in Evaporative Cooling Processes, ASHVE Transactions, Vol. 46, 1940.
10. Hixson, A. W., Scott, C. E., Ind. Eng. Chem., Vol. 27, 1935.
11. Mechanical Engineering 131 Laboratory Report, 1942, on file, Heat Transfer Office, Rm. 215, Engineering Bldg., University of California, Berkeley, Calif.
12. Johnstone, H. F., and Williams, G. C., Ind. Eng. Chem. Vol. 31, 1939.
13. Whitman, W. G., Long, L., and Wang, W. H., Ind. Eng. Chem., Vol. 18, 1926.
14. Boelter, L. M. K., Cooling Tower Performance Studies, ASHVE Transactions, Vol. 45, 1939.
15. Seban, R. A., Performance of Atmospheric Cooling Towers, on file, Library University of California, Berkeley, Calif.
16. Marchant, W. H., Investigation of Heat Transfer on Cooling Tower Splash Decks, on file Library, Stanford University, Palo Alto, Calif.

Table 4—Tabulation of Data and Results of Tests Performed with Screen Packings in the Spray Chamber

Run No	Pressure at Nozzles	Nozzle Discharge Rate	Water Conditions			Psychrometric Properties of Air							Mass Balance			Energy Balance			Log Mean Enthalpy Potential	Unit Volume Enthalpy Coefficient
			Inlet Temp.	Outlet Temp.	Sensible Heat Loss	Rate	Inlet Air			Outlet Air			Water vapor gained by Air	Measured Rate of Evap.	Diff.	Energy gained by air	Total Energy Loss by Water	Diff.		
							Dry-bulb Temp.	Wet-bulb Temp.	Relative Humidity	Dry-bulb Temp.	Wet-bulb Temp.	Relative Humidity								
	P	L_1	T_1	T_2	$L_1\Delta T$	G	t_{2DB}	t_{2WB}	R_2	t_{1DB}	t_{1WB}	R_1	$G\Delta H$	ΔL	D_L	$G\Delta h$	$L_2T_2h_2 - L_1T_1h_1$	D_h	$(\Delta h)_m$	$k_y a$
	psig	lbs. per hr.	°F	°F	Btu per lb	lbs. d.a. per hr	°F	°F	%	°F	°F	%	lbs. per hr.	lbs. per hr.	%	Btu per hr.	Btu per hr.	%	Btu per lb d.a.	Btu per hr./lb d.a./°F
Two-#8 Mesh Galvanized Screen Packings																				
7	35	7680	90.2	81.3	68,350	4490	72.8	66.5	71.7	81.8	81.8	100.0	50.2	56.8	-11.61	65,000	71,150	-8.65	12.1	161.2
8	30	7115	89.9	81.2	64,900	4500	73.7	68.3	75.8	81.3	81.3	100.0	43.5	46.6	-6.66	53,950	64,190	-12.83	11.96	135.7
1	25	6455	89.5	78.8	69,100	4550	70.5	62.4	63.5	78.6	78.1	97.9	47.9	55.4	-13.54	61,500	71,690	-14.20	13.7	144.1
9	24	6390	90.1	76.6	72,250	4575	71.4	62.4	57.0	78.6	78.6	100.0	53.9	56.8	-5.12	68,900	74,905	-10.7	14.55	141.9
2	20	5710	88.8	77.1	63,400	4565	62.8	55.6	63.4	74.9	73.8	94.9	45.5	56.8	-19.90	63,200	65,960	-4.19	16.8	109.1
3	15	4910	90.2	77.4	63,300	4655	70.1	60.6	52.5	75.9	75.7	99.3	47.0	55.4	-15.17	57,750	65,810	-12.25	15.2	119.0
10	12.2	4560	89.6	77.0	57,600	4575	71.4	61.5	56.5	75.1	74.9	99.1	42.3	44.7	-5.38	50,350	59,620	-15.6	14.62	112.6
4	10	3880	90.1	77.4	49,300	4570	69.2	60.1	58.9	74.2	73.3	97.2	39.7	43.7	-17.48	49,700	51,480	-3.46	16.3	86.5
6	7.5	3330	90.1	75.9	47,250	4575	71.9	58.8	44.8	73.3	72.0	94.1	41.5	46.6	-5.04	46,150	49,170	-7.93	16.9	80.0
5	5	2490	90.1	75.1	37,350	4565	73.7	61.5	49.3	72.2	71.4	97.5	35.5	33.5	+5.97	37,300	38,795	-3.85	15.4	69.3
11	3	1630	90.1	74.0	26,200	4615	67.8	60.1	64.1	68.9	68.1	86.5	17.3	16.75	+6.95	20,150	26,900	-24.86	15.2	48.2
Two-#4 Mesh Galvanized Screen Packings																				
12	34.9	7675	90.0	78.3	89,750	4515	63.9	57.5	68.5	78.8	78.8	100	57.1	67.0	-14.76	79,250	92,850	-14.65	15.25	188.1
13	30.0	7110	90.5	79.0	83,750	4460	67.8	58.5	56.1	79.0	79.0	↓	59.2	68.8	-14.1	77,000	84,990	-9.40	16.8	159.0
14	25	6515	90.3	79.3	71,600	4480	70.2	62.0	67.7	79.0	79.0		48.3	56.8	-17.9	66,400	74,380	-10.7	14.45	141.6
15	20	5805	89.5	78.8	62,100	4540	70.2	62.7	65.7	77.8	77.8		46.3	53.4	-13.3	59,100	64,600	-8.51	13.0	136.7
16	15	4920	90.4	78.8	57,000	4500	70.1	63.7	70.3	77.3	77.3		41.2	48.05	-14.25	52,900	59,225	-10.7	13.77	118.2
17	10	4020	90.3	77.6	51,000	4590	65.5	60.2	73.0	72.7	72.7		41.7	43.7	-4.58	45,500	52,995	-14.13	17.04	85.5
18	7.5	3430	90.3	76.8	46,300	4565	71.9	61.9	57.5	74.4	74.4		39.6	34.95	+13.30	46,000	47,865	-3.90	15.08	87.9
19	5	2585	90.0	76.2	35,650	4660	75.8	64.7	53.2	75.5	73.9	89.6	31.9	32.8	-2.75	35,100	37,00	-5.39	14.07	72.5
20	3	1585	90.0	75.6	22,800	4600	76.0	62.8	47.0	73.7	67.6	73.0	18.1	20.4	-11.26	16390	23639	-30.5	16.36	39.8



IMPORTANT TO A. S. H. V. E. MEMBERS

THE RATIONING OF FUEL OIL FOR 1943 - 44 IS CERTAIN.

Please fill in this questionnaire and return promptly to War Service Committee:

The A. S. H. V. E. War Service Committee has been invited to consult O. P. A. in working out Fuel Oil Rationing Plans for 1943-44. Your experience will be helpful.

(1) Your Name_____

Your Address_____

(2) HAVE YOU SERVED ON A FUEL OIL RATIONING BOARD, PANEL OR AS A CONSULTANT ON FUEL OIL PROBLEMS? YES ____ NO ____

(a) If answer is "YES" -- WHERE? _____

(b) If on a rationing board, how and by whom were you appointed? _____

(c) Were you requested to serve and then not called? YES____ NO ____

(3) WHAT DO YOU CONSIDER THE OUTSTANDING PROBLEMS THAT WERE REFERRED TO YOU AND HOW COULD THEY BE SIMPLIFIED?

(a) _____

(b) _____

(c) _____

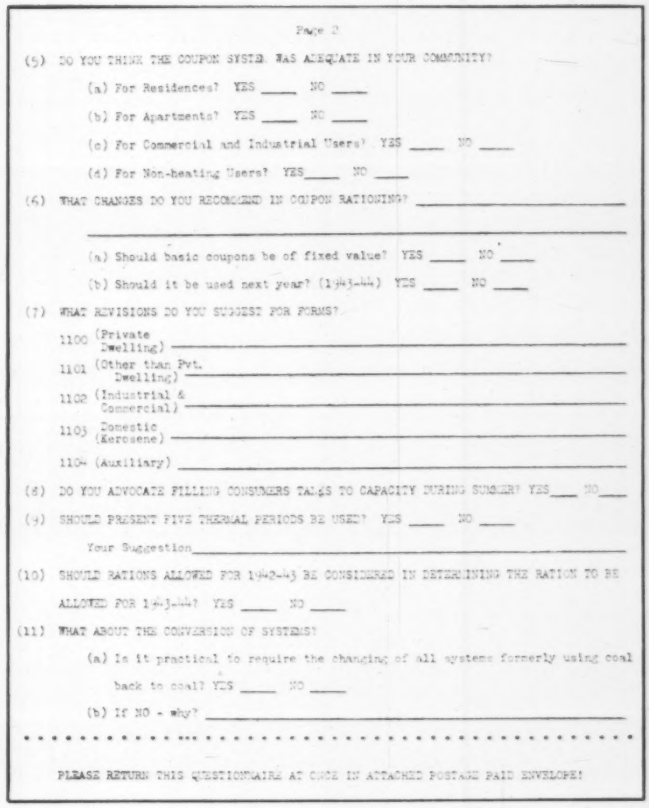
(4) DID YOUR BOARD USE THE FORMULA AND TABLES DEVELOPED BY O. P. A. FOR FUEL OIL RATIONING? YES ____ NO ____

(a) How did they fit your needs? _____

(b) Should the same formula and tables be used next year? YES ____ NO ____

(c) What changes would you suggest, if any? _____

WHY? _____



Page 2

(5) DO YOU THINK THE COUPON SYSTEM WAS ADEQUATE IN YOUR COMMUNITY?

(a) For Residences? YES ____ NO ____

(b) For Apartments? YES ____ NO ____

(c) For Commercial and Industrial Users? YES ____ NO ____

(d) For Non-heating Users? YES____ NO ____

(6) WHAT CHANGES DO YOU RECOMMEND IN COUPON RATIONING? _____

(a) Should basic coupons be of fixed value? YES ____ NO ____

(b) Should it be used next year? (1943-44) YES ____ NO ____

(7) WHAT REVISIONS DO YOU SUGGEST FOR FORMS?

1100 (Private Dwelling) _____

1101 (Other than Pvt. Dwelling) _____

1102 (Industrial & Commercial) _____

1103 Domestic (Kerosene) _____

1104 (Auxiliary) _____

(8) DO YOU ADVOCATE FILLING CONSUMERS TANKS TO CAPACITY DURING SUMMER? YES____ NO____

(9) SHOULD PRESENT FIVE THERMAL PERIODS BE USED? YES ____ NO ____

Your Suggestion_____

(10) SHOULD RATIONS ALLOWED FOR 1942-43 BE CONSIDERED IN DETERMINING THE RATION TO BE ALLOWED FOR 1943-44? YES ____ NO ____

(11) WHAT ABOUT THE CONVERSION OF SYSTEMS?

(a) Is it practical to require the changing of all systems formerly using coal back to coal? YES ____ NO ____

(b) If NO - why? _____

PLEASE RETURN THIS QUESTIONNAIRE AT ONCE IN ATTACHED POSTAGE PAID ENVELOPE!

Fuel Oil Rationing Questionnaire

By John Howatt, Chairman, ASHVE War Service Committee

THE RESPONSE to the questionnaire sent to members of the American Society of Heating and Ventilating Engineers in the states in which fuel oil rationing has been put into effect was very complete. Over 650 of the questionnaires were returned to the War Service Committee and the data from 22 states have been analyzed. A great many of the members expressed opinions on the different questions asked in the questionnaire, some of which were based upon actual experience obtained through service on a rationing board, some through experience gained while acting as consultant or advisor to those being rationed, and some through the members themselves having had personal experiences in fuel oil limiting orders.

The various suggestions and recommendations were so constructive as to indicate that those engineers who responded had been giving the fuel rationing problems serious consideration. However, in all returns there appeared the almost unanimity of thought that whatever decision is to be made relative to rationing of oil and conversion of plants from burning liquid to solid fuel must be made early and that advantage be taken of the nation's oil storage facilities by filling the consumers' tanks in summer, thereby preventing tanks from floating, preventing internal corrosion, and providing a better distribution of the load on the oil suppliers.

In response to Question 4-a, "How did the formula and tables developed for fuel oil rationing fit your needs," 47 per cent of those reporting stated the formula used worked out fairly satisfactorily; 20 per cent reported it would work with minor specific allowances for unusual conditions, and 33 per cent reported it was unsatisfactory. In reply to Question 4-c, "What changes would you suggest in the formula if any," 59 per cent recommended that a formula be used that considered actual heat loss more than did the general formula applied last season; the remaining 41 per cent offered a wide variety of suggestions whereby inequalities might be eliminated.

Several members supplemented the questionnaire with personal letters expressing their opinions and making their suggestions and recommendations more fully than could be done if they confined their replies strictly to the *"Yes"* or *"No"* of the questionnaire. Many of the suggestions offered are sound. They have been filed in the Society headquarters office for reference and consideration in dealing with future fuel rationing problems. Summaries giving a cross section of this survey of the opinions of members of the American Society of Heating and Ventilating Engineers have been given to the Office of Price Administration, Fuel Rationing Division, Washington, D. C., with the hope that consideration will be given to them wherever they can be fitted into the fuel rationing program. The force of these opinions has already contributed toward bringing about modifications in regulations that will simplify the work for Boards and distributors and make the whole program more workable.

KEEP HEATING PLANT AT PAR

In the April issue of *Coal-Heat*, Pres. M. F. Blankin, under the title of Summer Service, presents some suggestions on the care of heating equipment in order to obtain the greatest efficiency for the duration of the war. He points out that under conditions such as the present, "it is necessary to make the owner very conscious of his heating system by enlisting his cooperation and interest—with the thought of making him as comfortable as possible under the circumstances."

He suggests that home owners have an examination made of their heating

equipment in the spring by a competent heating contractor for a check-up on piping, valves, ducts, dampers, regulators, control equipment, filters, motors, blowers, and other moving parts.

He points out that where substitute fuels must be used proper instruction in firing is essential and some adjustment of apparatus is necessary for best results. He also points out that, "if your heating system has not been performing to your satisfaction, you need a heating contractor or consulting engineer—and the advice he gives you may enable you to live next winter in much more comfort than you did this last season, and with perhaps no more fuel than you had this past winter.

"The heating system cannot work to keep you comfortable 200 to 250 days of the year if you neglect it or assume that everything is right when you turn the switch.

"It will pay to repair, replace and remodel heating systems this summer, so that they will perform properly and last for the duration."

BUY COAL EARLY

H. A. Gray, Deputy Solid Fuels Coordinator for War, has asked cooperation in making effective a program to maintain production, transportation and distribution of coal continuously throughout spring and summer in order to meet this year's heavy war time fuel requirements. This cooperation can best be shown by urging that the consumer place orders for coal early and urging acceptance of delivery wherever possible during the summer months instead of waiting until cold weather has arrived before taking action to provide a fuel supply. In this way mines will have reason for continuous operation to get the coal out of the ground to fill orders and transportation facilities from mines to distribution centers and local dealers will be able to have a continuous twelve months operation. This will help to avert an impending fuel shortage next winter.

The American Society of Heating and Ventilating Engineers is concerned with all phases of the fuel problems and as an organization desires to cooperate in every way it can in any program affecting the production and conservation of fuels.

It is therefore recommended that each member of the American Society of Heating and Ventilating Engineers take such action for himself covering his own fuel requirements and urge his organization and associates to make provisions to order and store coal early for next winter's requirements. It is further recommended that this message be read in each Chapter at its May meeting and that each Chapter take steps to obtain full publicity for this cooperative program.

GOVERNMENT URGED TO PREVENT INTERRUPTION OF COAL PRODUCTION

Action was taken by the War Service Committee of the Society urging appropriate government representatives to take action that would prevent any stoppage of coal production.

Dr. John R. Steelman, Chief U. S. Conciliation Service
Washington, D. C.

Dear Sir:

This letter confirms a telegram sent you on this date (April 8, 1943) relative to the urgent need of keeping coal mines operating without interruption:

SINCE FUEL IS SO ESSENTIAL TO THE WELFARE AND SECURITY OF THE NATION AT THIS TIME AND SINCE THE MORALE OF OUR PEOPLE WOULD BE SERIOUSLY DISTURBED BY ANY STOPPAGE IN COAL PRODUCTION, THE WAR SERVICE COMMITTEE OF THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, REPRESENTING 3,000 MEN TRAINED AS EXPERTS IN PROBLEMS OF COMBUSTION AND HEATING AND WHO ARE CONSTANTLY DEALING WITH PROBLEMS RESULTING FROM RATIONING, URGES THAT NO STOPPAGE OF WORK BE PERMITTED TO TAKE PLACE UNDER ANY CIRCUMSTANCES AND THAT THE COAL MINES BE KEPT IN FULL OPERATION UNTIL NEGOTIATIONS BETWEEN OPERATORS AND MINERS BE CONCLUDED IN ACCORDANCE WITH THE PROVISIONS OF THE GOVERNMENT-LABOR-INDUSTRY AGREEMENTS AGAINST STRIKES DURING THE WAR.

With a coal production requirement of 660,000,000 tons from mines in the United States in 1943 to meet normal needs and the unusual demands brought about by the war effort, any shut down of facilities at any time during the year, meaning a loss of 2,000,000 tons in production for every day mines are closed, would make it practically impossible to meet the production goal set as the minimum requirements.

A National Government-Labor-Industry agreement provides that the final determination of disputes between employers and employees shall be settled by hearings before the National War Labor Board. A temporary agreement between coal mine operators and miners has been reached through which mines will be operated for thirty days after April 1st during the period of negotiation between operators and miners. Since there is a possibility that a permanent agreement cannot be reached within thirty days, and since fuel is so essential to the welfare and security of our nation at this time, the War Service Committee of the American Society of Heating and Ventilating Engineers representing 3,000 men trained as experts in problems of combustion and heating and who are dealing with many fuel problems brought by rationing, urges that every effort be made to keep the coal mines in full operation until negotiations between operators and miners be concluded.

Yours very truly,

WAR SERVICE COMMITTEE, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
John Howatt, *Chairman*

ASRE MEETING JUNE 1-3

The officers of the American Society of Refrigerating Engineers announced that the theme for their technical sessions at the 30th Spring Meeting, June 1-3, Hotel Statler, Cleveland, will be low temperature applications of refrigeration.

The meeting will be held under the auspices of the Cleveland Section and H. D. Andress is the General Chairman. The program announced by Prof. Burgess Jennings, Chairman of the Program Committee, provides for three technical sessions, with numerous interesting and timely topics involving insulation, corrosion, synthetics, food preservation, and transportation.

NDHA ANNUAL MEETING IN PITTSBURGH

Pittsburgh has been selected for the National District Heating Association's 34th Annual Meeting to be held June 9-10 as announced by John F. Collins, Jr., Chairman. Some of the topics to be discussed at the sessions will be of interest to those in the heating and ventilating field, such as, hot water consumption of buildings, changes in hot water and steam due to the war, automatic temperature control installations, experience with damage to insulation by flooding, preventing of corrosion in banked and stand-by boilers, and also meter maintenance problems encountered due to difficulty of obtaining critical materials. There will be a total of 28 interesting papers presented at these sessions. The election and induction of officers will take place at the closing session.

Members on Active Duty*

U. S. Army

ADAIR, JAMES S., Cpl., 20th T.S.S.

BACHOFER, HENRY A., JR., Sgt., 87th Air Base Squadron.

BADGETT, W. HOWARD, Major, Fifth Army Service Forces Staff Course, Command and General Staff School.

BARNES, HUGH S., Capt., 99th C. A. (aa)

BERNARD, EDGAR L., Lieut., 23rd Armored Engr. Bn.

BERZELIUS, CARL E., Major, Bn. Comdr.

BOYD, R. L., JR., Pvt., 74th T.E.F.T. Squadron.

BROWN, HARPER J., 1st Lt., Ordnance Dept.

BRUNDAGE, F. WARD, 1st Lt., 423rd C. A.

BURNS, FRANK G., Capt., Infantry.

CAMPBELL, ALFRED Q., JR., Capt., F. A.

CAMPBELL, GEORGE W., Capt., Air Corps.

CARLOCK, MARION F., Capt., Corps of Engrs.

CASKEY, LUTHER H., JR., 1st Lt., Co. F, 38th Engrs.

CHAPIN, HARVEY G., 1st Lt., Air Corps.

CHASE, R. E., JR., Pfc., 417th Ordnance Dept. Avn.

CHEESEMAN, EVANS W., Capt., Personnel Officer.

CLARK, ALBERT C., Capt., F. A.

CLARK, JAMES R., Pvt., Air Depot Supply Sqdn.

CLEMENS, JOSEPH D., 2nd Lt. (Engrs), Air Corps.

CLOW, SHERWOOD A., 2nd Lt., Signal Corps.

COX, VERNON G., Major, C. A., Hq. 29th A.A.R.T.B.

CRAWFORD, ARTHUR C., Capt., Q.M.C.

CROLEY, JACK G., 1st Lt., 76th C. A.

CROPPER, ROBERT O., 1st Lt., Q.M.C.

DABBS, JOHN T., 1st Lt., C. A.

DANIELSON, WILMOT A., Brig.-Gen., Q.M.C.

DEAN, DAVID, Pvt., 30th E.R.T.C., 1st Platoon.

DIAMOND, DAVID D., Staff Sgt., 801st S. T. Bn., Co. B.

DICKSON, ROBERT W., JR., Lt., 40th Bombardment Group.

DRUM, LEO J., JR., 2nd Lt., (Hq. Special Troops—2686).

DYER, W. S., Pvt., 2nd Q.M.T.R., Co. B.

ESCHENBACH, SAM P., 1st Lt., 62nd C. A. (aa).

FARLEY, W. S., Capt., 104th Q.M. Regt.

FELDSTEIN, HAROLD, Capt., Ordnance Dept.

FERDERBER, MURRAY, Capt., M.C.

FITZGERALD, WILLIAM E., 1st Lt., 99th Inf. Div.

FLARSHEIM, C. A., 2nd Lt., E.R.C., Air Corps.

FORDERBRUGGEN, KEVIN J., Major, 65th C.A. (aa).

FOSTER, JOHN G., Lt., Air Corps.

FRANKLIN, S. H., JR., Major, Ordnance Dept.

FREEMAN, ALFRED W., 2nd Lt., Air Corps.

FRIEDMAN, D. HARRY, Capt., Post Engr.

GAULT, GEORGE W., Capt., Corps of Engrs.

GONZALEZ, RAFAEL A., Capt., Ordnance Dept.

GRABMAN, HENRY B., Lt., 36th Engrs., (c).

GREEN, EVERETT W., Pvt., 87th Bn.

HAMILTON, J. B., 1st Lt., Corps of Engrs.

HAWES, HAROLD D., Instructor, A.A. School.

HENDRICKSON, W. B., Staff Sgt., Air Corps Tech. School.

HERBERT, JAMES S., 1st Lt., Co. A, 385th Engrg. Bn.

HERBERT, RICHARD J., Lt., Air Corps.

HILL, EDWARD, JR., Capt., F.A.

HOLMES, RICHARD E., 1st Lt., Ordnance Dept.

HOOVER, W. L., 2nd Lt., Corps of Engrs.

HUBBUCH, N. J., Student, Communications Div., Air Corps.

HUNT, MACDONALD, Capt.

HUST, CARL E., Capt., Ordnance Dept.

HUTCHINSON, B. Lee, Jr., 2nd Lt., Air Corps (Engrg. Officer.).

IBISON, JAMES L., Capt., Post Engr.

INMAN, C. M., 1st Lt., Air Corps.

JONES, JAMES T., 2nd Lt., Engr. Reserve Corps.

KELLY, OLIN A., Aviation Cadet, Air Corps.

KILLOREN, DONALD E., Hq. Co., 15th Infantry.

KLUCKHURN, F. H., A/C—AAFTS.

KOENIG, ANDREW C., Pvt.

KUMMER, CALVIN J., 1st Lt., 72nd F.A.

KURTZ, ROBERT W., Capt., Ordnance Dept., Executive Officer.

LENONE, J. M., Lt.-Col., Corps of Engrs.

LIGHT, JOHN C., Capt., Ordnance Dept.

LLOYD, EDMUND H., 1st Lt., Office, Chief of Engrs.

LYON, DOUGLAS M., Pvt., Co. B, 11th Training Bn.

MACEACHIN, GRAHAM C., Major, Corps of Engrs.

MACGREGOR, CECIL M., Capt., F.A.

MALIN, BENJAMIN S., Capt., Ordnance Dept.

MARINO, FRANK A., Tech. Sgt.

MARSTON, ANSON D., Lt.-Col., C.E.

MCCAIN, H. KING, Lt., Quartermaster School.

MCDERMOTT, JOHN P., Corps of Engrs.

MCGOWN, F. H., JR., Pfc., 7th T.S.S.

MCKAY, ALBERT W., Capt., Ordnance Dept.

MORAWECK, ALVIN H., JR., Lt., CRTC.

MORTON, HAROLD S., Lt.-Col., Ordnance.

MOORE, H. W., 1st Lt., Cincinnati Ordnance Dist.

MUIRHEID, JOHN G., Pvt., Co. D. 4th Bn.

NEAL, JAMES P., Capt., Ordnance Dept.

NORRINGTON, WALTER L., 1st Lt., Ordnance Dept.

OTTS, JOHN G., 1st Lt., Ordnance Dept.

PARKER, R. A., 1st Lt., 749th M.P. Det.

PEISER, MAURICE B., Aviation Cadet.

PELLMOUNTER, THOMAS V., 2nd Lt., 55th Ordnance Co.

PLOSKEY, E. J., Corporal, 40th Ordnance Co.

PLEUTHNER, R. L., Air Corps Flying Cadet.

PRAWL, FRANK E., Capt., Ordnance Dept.

PREBENSEN, H. J., Major, Ordnance.

PRICE, CHARLES F., Cadet, Co. F., 3rd Q.M. School Regt.

REIF, ALLAN F., Colonel, 74th Infantry.

RHINE, GEORGE R., Major, Ordnance Dept.

RICHARDS, GUY H., Lt.

RIESECK, W. L., 2nd Lt., Corps of Engrs., U. S. Army Reserve.

ROBERTS, H. P., Pvt., Btry. C, 419 (A) F.A.

RODEFFER, E. W., Pvt.

ROSSITER, I. J., Lt., F.A.

ROTHMAN, S. N., Capt., Sn., Occupational Hygiene Div.

RUEMMELE, ALBERT M., 1st Lt., Ordnance Section PRGD.

SANDFORT, JOHN J., Capt., 303 F.A. Bn.

SATTERLEE, HARRY A., 2nd Lt., Ordnance Dept.

SAUERWEIN, G. K., Major, Ordnance Dept.

SCHLICK, PAUL F., Colonel, 216th C.A.

SEMEL, EDWARD, Pvt., 401st Training Group, Flight H.

SHARP, JOHN R., Major, Corps of Engrs.

SHEARER, WM. A., JR., 2nd Lt., Corps of Engrs.

SLOANE, DAVID J., 56th General Hospital.

SNYDER, EDWIN F., 2nd Lt., Corps of Engrs.

SOBEL, FRANK, Pvt., Co. A., 101 M.P. Bn.

SPENCE, ROBERT A., Lt., Ordnance Dept.

STEVENS, E. K., Capt., Liaison Officer.

STEVENS, KENNETH M., 1st Lt., 958th C.A.

SUTCH, H. C., 1st Lt., Umatilla Ordnance Depot.

STERNER, DOUGLAS S., Capt., 282nd Q.M.C.

STROTHER, WM. E., 1st Lt., Corps of Engrs.

THOMAS, RALPH C., Capt.

TRAYNOR, H. S., Lt., Corps of Engrs.

VANNOUHUYS, HERBERT C., 1st Lt., Signal Corps.

VINSON, NEAL L., 1st Lt., Corps of Engrs.

WATSON, GERALD M., Pvt., 94th Div. Arty.

WEATHERBY, E. P., JR., Capt., Avn.—8th Fighter Command.

WEAVER, J.v.O., Lt.-Col., A.C.

WERNER, PHILIP, Reserve Officer, Signal Corps.

WILLS, FRED W., A/C, 5th Airforce Flying Training Det.

WILSON, WESTRAY E., Lt.-Col., Q.M.C.

WOLIN, MILTON, Air Corps.

ZEIGLER, DONALD, A/C, B.T.C. No. 1.

ZINK, DAVID D., Major, G.S.C., 1st Arm'd Corp.

U. S. Navy

AKERS, GEORGE W., Lt.-Comdr., U.S.S. Markab.

ANDREWS, WM. G., Warrant Officer, Mach. A.V. (s), U.S.N.R.

ASH, R. S., Ensign, U.S.N.R.

BABER, JOHN E., Lt., U.S.S. Bainbridge.

BAKER, ROLAND H., Comdr., U.S.N.R.

BOUILLON, LINCOLN, Lt. (CEC), U.S. N.R.

BRAUN, CHARLES R., JR., Midshipman, U.S.N.R.

BRISSENDEN, CARROLL W., Lt. (jg), U.S.N.R.

CARTER, J. H., Lt.

CARY, EDWARD B., Comdr. (CEC), U.S.N.R.

*Compiled as of April 15, 1943.

CHAPMAN, WILLIAM A., JR., Lt., U.S. N.R.
CHILDS, LEWIS A., Lt., E-V (s), U.S. N.R.
COOPERMAN, E., S/2c A.B.H.T.U.—N.A.S.
COVER, R. R., Warrant Officer, E-V (s), U.S.N.R.
CURLEY, ELLIS I., U.S.N.R.

DAVIDSON, JOHN C., Lt. (jg), U.S. N.R.

EGGERS, W. K., Ensign.
EUTSLER, EUGENE E., JR., Lt., U.S. N.R.
EVANS, RICHARD W., Lt.-Comdr.
EVERETTS, JOHN, JR., Lt. O-V (P), U.S.N.R.

FLORETH, JOHN J., Lt. (jg), U.S.N.R.
FORBES, HOMER B., JR., Ensign, U.S. N.R.

GREGG, STEPHEN L., Lt., U.S.N.R.

HERO, GEORGE A., JR., Lt.-Comdr., U.S.N.R.
HERRE, HAROLD A., Ensign, E.V.S., U.S.N.R.
HERTZLER, JOHN R., Lt., U.S.N.R.
HOLLAND, W. T., Lt. (jg), U.S.N.R.
HOUGHTEN, F. C., Lt.-Comdr., U.S. N.R.

JOHNSON, LESLIE O., U.S.N.R.
JORDY, J. J., Lt.

KAHN, CHARLES R., JR., Lt. (jg), U.S. N.R.
KEYES, M. W., Lt. (jg), U.S.N.R.
KILLIAN, W. J., Lt. (jg), U.S.N.R.
KOLB, ROBERT P., Lt.-Comdr., U.S. N.R.

LADD, DAVID, Lt.-Comdr., U.S.N.R.
LANDAUER, LEO L., Lt. (CEC), U.S. N.R.
LANGE, FRED F., Lt., U.S.N.R.
LEVINE, LAWRENCE J., Ensign, U.S. N.R.
LEVITT, LEROY L., Lt. (jg), U.S.N.R.
LIEBLICH, MURRAY, Ensign, U.S.N.R.
LOCKE, ROBERT A., Lt.-Comdr., U.S. N.R.

MABLEY, LOUIS C., Lt.-Comdr., U.S. N.R.
MATHEKA, CHARLES R., U.S.S. Tattnall.
MATTHIES, LEO A., Ensign, U.S.N.R.
MAY, MAXWELL F., Lt., U.S.N.R.
MCDOWELL, HARRY L., Ensign, U.S. N.R.
MILLARD, JUNIUS W., Lt., Organized Reserve.
MITCHELL, A. J., Lt. (jg), U.S.N.R.
MORSE, LOUIS S., JR., Lt. (jg), U.S. N.R.

PAETZ, G. A., Ensign, U.S.N.R.
PARKINSON, JOHN S., Lt.-Comdr., U.S. N.R.
PELLER, LEONARD, Lt. (jg), U.S.N.R.
POWERS, EDGAR D., Lt. (jg), U.S.N.R.

QUEER, E. R., Lt. (jg), U.S.N.R.

RILEY, JOHN N., Lt. (jg) E-V (s), U.S.N.R.
RODEE, E. J., Lt., U.S.N.R.
ROGERS, CHARLES S., Lt. (jg), U.S. N.R.

SCHECHTER, JACK E., Lt. (jg), Naval Training School.
SHAPIRO, CHARLES A., Ensign D-V (s), U.S.N.R.
SIMPSON, ROBERT L., Lt. (jg), U.S. N.R.
STACEY, ALFRED E., JR., Capt., U.S. N.R.
STEEL, R. JUSTIN, Lt., U.S.N.R.
STERNE, C. M., Lt.-Comdr., U.S.N.R.

TIMMIS, W. W., Lt.-Comdr., U.S.N.R.

A Member a Day Is the 1943 Goal

The growth of our Society will be proportionate to the efforts of every member. Prospects are plentiful and many will be glad to join when they are invited. Our goal has been set at 300 new members for 1943. Through individual efforts and through our chapter committees this should be accomplished.

Our President has set a personal quota of 25 new members this year. This is inspiring to the membership committee as well as is the pledge of a Life Member who has been sending in several applications each year.

The influence of our Society is proportionate to the activities of its membership. The ASHVE has demonstrated that it can be of real public service in war time and now is the time to extend its influence.

E. K. CAMPBELL, Chairman,
Membership Committee.

TURNER, JOHN P., JR., Lt. (jg), U.S. N.R.

URDAHL, T. H., Comdr., E-V (s)

VAN ALSBURG, JEROLD, Lt., U.S.N.R.

WESTPHAL, N. E., Ensign, U.S.N.R.
WORKMAN, ALBERT E., Lt. (jg), U.S. N.R.

YOUNGER, JOHN R., U. S. Naval Training School.

ZUROW, WILLIAM A., Ensign.

Foreign Members

ARMOUR, EDSON G., Royal Canadian Air Force.

BALLANTYNE, GEORGE L., Instructor, Royal Canadian Air Force.
BARRETT, CAMPBELL M., Canadian Active Service Forces.
BISHOP, JOSEPH W., Lt.-Col., Canadian Active Service Forces.
BODMER, EMMANUEL, Lt., Air Force.
BOWERMAN, E. L., Flying Officer, Royal Canadian Air Force.
BUTT, RODERICK E. W.

DANIEL, WILLIAM E., 2nd Lt., Royal Artillery.
DOWLER, EDWARD A., 1st Lt., Canadian Army, Royal Canadian Engrs.

FOX, JOHN H., Major, Ordnance Co.

JOHNS, CHARLES F., Flight Lt., Royal Canadian Air Force.

KITCHEN, WILLIAM H. J., Lt. (sb), Royal Canadian Naval Volunteer Reserves.

LABONNE, HENRI, Lt., "Les Fusiliers de Sherbrooke."

MACLACHLAN, VICTOR D., Flight Lt., Royal Air Force Volunteer Reserves.

NORFOLK, LESLIE W., Lt.-Col., Royal Engrs.

PENNOCK, WILLIAM B., Lt.-Col., Royal Canadian Engrs.
POUGHER, BERNARD R. E., Sgt., 110 (el) A.T. Coy R.E.
PRICE, ERNEST H., Lt., Royal Canadian Engrs.
PRYKE, JOHN K. M., Capt., Royal Army Ordnance Corps.

RICHARDSON, ROBERT D., Bombardier, Royal Regiment Artillery.
ROBINSON, JACK A.

SMITH, GERALD E., Royal Canadian Engrs.

WILKINSON, ARTHUR, Flight Lt., Royal Canadian Air Force.
WOOD, ALFRED W., Royal Canadian Air Force.

PRESIDENT BLANKIN VISITS CHAPTERS

In May Pres. M. F. Blankin has speaking engagements scheduled for cities in the middle west, Pacific Coast and Canada. His itinerary is: *May* 10—Illinois Chapter, Chicago; *May* 12—Joint Meeting of Nebraska Chapter and Omaha Engineers Club, Omaha; *May* 17—Southern California Chapter, Los Angeles; *May* 19—Golden Gate, San Francisco; *May* 20—Oregon Chapter, Portland; *May* 24—Pacific Northwest Chapter, Seattle; and *May* 28—Manitoba Chapter, Winnipeg.

During April President Blankin's activities included addresses at meetings of Atlanta Chapter, Delta Chapter at New Orleans, South Texas Chapter at Houston, Bexar County Society of Professional Engineers at San Antonio, North Texas Chapter at Dallas, Oklahoma City Chapter, Kansas City Chapter, and Iowa Chapter at Des Moines.

Chapters Can Cooperate in Conversion Campaign

Engineers who are qualified and who are in a position to render engineering service to owners or operators of fuel burning plants in the conversion program should be listed and made available in their community. This work should be done by the Local Chapters of ASHVE which can canvass the qualified engineers in their community, whether they belong to the Society or not, compile such a list and give publicity to it, making it available through local fuel distributors, OPA Regional Offices and through press releases. The War Service Committee considers that such action by Local Chapters now would be in the public interest.

SUMMARY OF LOCAL CHAPTER MEETINGS

Chapter	Meeting Date	Subject	Speakers	Other Features	Attendance	Attendance Ratio*
Cincinnati	April 13	High Lights Upon Fan Selection from the Acoustic Viewpoint.	T. A. Walters	Members signed get-well cards for L. F. Hudepohl and T. D. Boyd.	26	0.54
	March 9	Hot and Low Temperature Insulation.	R. H. Heilman, Sr., Industrial Fellow, Mellon Institute, Pittsburgh, Pa.	General discussion of Chapter's affairs.	35	0.72
Golden Gate	April 7	Ventilating, Heating and Air Conditioning as Applied to Warships.	Lt. (s.g.) John Everetts, U.S.N.	Nomination of officers for next year.	32	0.53
	March 3	Some Engineering Problems of the New Vegetable Dehydration Industry.	W. B. Van Arsdel, Chief, Engrg. and Development Div., Western Regional Research Laboratory, U. S. Dept. of Agriculture, Albany, Calif.	Report on Cincinnati Meeting by Dr. B. M. Woods.	31	0.50
Illinois	April 12	The Drying of Foods. The Spray Method (liquid drying). The Tunnel Method (vegetable drying).	Samuel Van Deest, Douthitt Corp. D. A. Forberg, Air Comfort Corp.	Paper prepared by Miss Morilla Carveth, Consultant on Food Dehydration, "History and Present Scope of Food Dehydration" was read.	110	0.803
Massachusetts	March 16	Phases of Hot Water Heating.	M. F. Blankin, Philadelphia, Pa., Pres. of ASHVE.	Treasurer reported purchase of two additional Series F War Bonds	42	0.73
Michigan	March 8	Saran Plastics Synthetics—Plastics—Frontiers	P. M. Jensen, Dow Chemical Co. G. C. Gress, Monsanto Chemical Co.	Movies—Plastics. This was joint meeting with ASRE.	92	0.72
	February 15	Experiences Gathering Electrical Equipment for Edison Institute Museum.	J. W. Bishop, Ford Motor Co.	Music by Texas Ranch Boys, Ford Motor Co. Movies—A. E. Knibb.	81	0.85
	April 12	The Manpower Problem in Engineering.	Dr. B. M. Woods, University of California, Berkeley, Calif.	Movies — Michigan Angler—Michigan Trout Fishing.	47	0.51
Minnesota	March 1	Construction of the Alaskan Highway.	H. B. Pehrson.	Colored Moving Pictures Shown.	32	0.44
	February 1	Method of Testing 30 and 50 Calibre Small Arms Ammunition.	J. R. Roberts, Chief, Ordnance Inspector, Twin Cities Ordnance Plant.	Sound Movie Film illustrating many of tests. William McNamara and M. H. Bjerken reported on Society's Annual Meeting in Cincinnati.	33	0.46
	January 4	Future Highway Transportation.	W. F. Rosenwald.	Discussion of Annual Meeting of Society.	21	0.27

Chapter	Meeting Date	Subject	Speakers	Other Features	Attendance	Attendance Ratio*
Montreal	March 15	Refrigeration.	R. C. Rodger, Chief Steam Engr., Canadian Copper Refiners, Ltd., Montreal.	Slides.	29	0.47
New York	March 15	Engineering War Training. The program featured the type and volume of engineering training in refresher courses for existing engineers as well as Specialized training for non-engineers by national educational institutions. The various draft deferment procedures by employers for engineering employees was explained in detail as well as the probable allocation of older engineers to defense industries. A picture of the engineering fields now critically short of personnel was presented with methods of retraining for new industries.	M. C. Giannini, Professor of Htg. and Air Cond., Dir. of War Training, N.Y. University. A. B. Newman, Dean of City College of New York, and Regional Training Advisor, War Manpower Com. H. H. Armsby, Field Coordinator, Secretary of Nat'l. and Regional Advisors Committee of Engrg., Science and Mgmt. War Training—U. S. Office of Education. Maj. J. L. Wettlaufer, U. S. A., N. Y. State Regional Field Officer of National Selective Service System. Samuel Moore, Professional Div., U. S. Employment Service, New York City.	Introduction of Carl H. Flink, new Technical Secretary of ASHVE, by A. V. Hutchinson.	42	0.28
Northern Ohio	April 12	Prefabricated Housing Projects.	R. T. Cutting.	Election of Nominating Committee.	44	0.66
North Texas	March 15	America Can Give It (sound movie) Heating and ventilating in car and plane of the future.	A. L. Henderson, General Motors Corp.	Regular Discussion.	43	0.63
Ontario	April 5	Ladies' Night. Let's Talk About the Men.	Miss Margaret Brown.		74	0.74
Philadelphia	March 11	Training of War Production Personnel.	J. W. Converse, Dir., Training Personnel of Baldwin Locomotive Works.	Motion Pictures on: Milling Machine Operation. Use of Vernier. Making Tanks. Battle of Song of the U. S. Marines.	50	0.43
St. Louis	April 6	Chemicals in the Future.	W. K. Menke, Development Dept., Monsanto Chemical Co., St. Louis, Mo.		22	0.39
Southern California	March 10	Industrial Future of Los Angeles.	J. F. Bone, Mgr., Industrial Dept., Los Angeles Chamber of Commerce.		42	0.33
Washington, D. C.	March 10	Accomplishments of ASHVE in Wartime.	M. F. Blankin, Philadelphia, Pa., President, ASHVE.	Dinner.	35	0.35

Chapter	Meeting Date	Subject	Speakers	Other Features	Attendance	Attendance Ratio*
Western Michigan	March 22	The Flow of Air and Gas in Various Systems.	S. H. Downs, Kalamazoo, Mich., 1st Vice-Pres. of ASHVE.	Held in connection with annual short course in warm air heating at Michigan State College. Guests represented Canada, Illinois, Michigan, Ohio and Washington, D. C., Chapters.	60	1.11
Western New York	March 22	Our Society's Activities in Wartime.	M. F. Blankin, Philadelphia, Pa., President of ASHVE.	Joseph Davis presented slate of officers to be voted on at next meeting. W. R. Heath and Mr. Davis were appointed to audit the 1942-43 record of Treasurer and his report.	56	1.02
	February 8	Industry in War and Peace.	C. E. Harrington, Chief Engr., Amphibian Car Corp.	L. P. Saunders gave resume of the Annual Meeting in Cincinnati, and announced that he was appointed chairman of Standards Committee.	23	0.42
Wisconsin	March 15	Status of the Engineer in Russia (informal coffee talk). Food Dehydration, Methods and Equipment.	Mr. Harris, Secretary of Council of American Soviet Friendship. J. W. Chamberlin.		53	0.73

*The attendance ratios shown represent the meeting attendance divided by the Chapter membership. These will be useful as a partial indication of interest shown by local chapter members in various types of subjects programmed by other local chapters, and may be helpful in deciding on subjects for other chapter meetings.

J. J. HERLIHY SUCCUMBS AT 85

Word has just been received of the death of Jeremiah J. Herlihy of Chicago, a Life Member of the Society. Mr. Herlihy was in his 85th year at the time of his death, and before his retirement, for many years conducted a successful contracting business in Chicago, specializing in heating and ventilating.

He was born July 15, 1858 at Cork, Ireland, and attended the Agricultural College in Dublin. He entered the heating business in Chicago as an apprentice with the John Davis Co. He received his shop training with this company and George E. Dixon and Co. For a while he served as foreman and superintendent of the latter firm, and was responsible for the heating and ventilating equipment in many large buildings in Chicago and other midwestern cities.

In 1929 Mr. Herlihy became eligible for Life Membership in the Society and for many years was active in the affairs of the Illinois Chapter and the Chicago Master Steamfitters Association. The Officers and Council regret the loss of a loyal member and send their deepest sympathy to his family.

J. T. MACHEN DIES SUDDENLY

The many friends of James T. Machen, Assistant Vice-President and Manager of Agencies, for the Ric-wiL Co., Cleveland, Ohio, will learn with sorrow of his sudden passing March 31, 1943, at the age of 34.

Mr. Machen's untimely passing occurred in Cleveland while attending a business conference of his company. He was born at Laurens, S. C., April 15, 1908, and he was a graduate of the local schools. He then attended Citadel College in South Carolina, and graduated from the University of Florida in 1929 with a B.S. degree.

He became associated with the Ric-wiL Co., immediately upon graduation from College, and served in the company's offices at Atlanta, St. Louis, Chicago and Cleveland.

Mr. Machen took an active interest in the Society's activities and was also an active member of the National District Heating Association. He was a 32nd degree Mason, and was active in other fraternal organizations, including the Garden City Blue Lodge, a Shriner at the Medinah Temple, and a member of the Baptist Church, all of Chicago.

Brief services were conducted at the DeVand Funeral Home in Cleveland on the 2nd of April and services were conducted at his home at Laurens, S. C., on the 4th of April, and interment took place in that city.

Mr. Machen is survived by his mother, Mrs. Pearl D. Machen, and two sisters, to whom the Officers and Council have expressed sincerest sympathy.

DEATH OF B. H. JESSUP

Word has been received of the passing of Benjamin H. Jessup, on February 24, 1943. Mr. Jessup was born at Stamford, Conn., September 30, 1888, and at the time of his death was President of Richards and Jessup Co., Inc., Stamford, a position he had held since 1922.

Mr. Jessup spent all of his active business career in Stamford, and his firm was responsible for the installation of heating, ventilating and other mechanical equipment in many buildings in New England.

Mr. Jessup joined the Society in 1937 and was active in the organization of the Connecticut Chapter of the Society.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 31 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by May 15, 1943, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
ALEXANDER, KEITH O., Sales Engr., Neil H. Peterson Co., San Francisco, Calif.	N. H. Peterson	C. L. Peterson
	H. V. Hickman	O. W. Johnson
BALLAGH, A. BRUCE, Sales Engr., B. F. Sturtevant Co. of Canada, Ltd., Toronto, Ont., Canada.	A. H. Blake	S. A. Jennings
	V. J. Jenkinson	R. S. Mathison
BARLOW, F. JOHN, Htg. & Vtg. Engr., A. O. Smith Corp., Milwaukee, Wis.	H. W. Schreiber	J. R. Vernon
	O. A. Trostel	F. W. Goldsmith
BECKER, GEORGE E., Service Mgr., Frigid Refrigerator Service Corp., St. Louis, Mo.	B. C. Simons	J. D. Coad
	H. W. McLarney	E. A. Freund
CATLETT, WILLIAM ALTON, Owner, Catlett Engineers, Dallas, Texas.	L. S. Gilbert	J. R. Dowdell
	W. H. Moler	L. C. McClanahan
CAUHORN, A. V., Owner, A. V. Cauhorn Co., Detroit, Mich.	W. F. Tydings	T. H. Mabley
	H. M. Keyser	E. Feinberg
EVANS, W. H., Gen. Mgr., Minneapolis-Honeywell Regulator Co., Ltd., Toronto, Ont., Canada.	V. J. Jenkinson	J. P. Fitzsimons
	S. A. Jennings	R. S. Mathison
FLINN, JAMES D., Engr., J. J. Nolan & Co., Memphis, Tenn.	R. H. Hoshall	J. J. Nolan
	C. E. McCoy	*W. I. Butler
GUILLORY, JOHN M., Mgr., Ind. & Com. Engrg. Div., New Orleans Public Service, Inc., New Orleans, La.	G. E. May	G. C. Kerr
	J. S. Burke	W. H. Dudley, Jr.
HOULIHAN, EDMUND T., Asst. Sales Mgr., Taco Heaters, Inc., New York, N. Y.	R. R. Emerson	M. F. Blankin
	J. R. Murphy	R. L. Blanding
KIRSCHHOFER, FERD J., Owner, Federal Home Heating Co., Buffalo, N. Y.	Joseph Davis	C. A. Gifford
	S. M. Quackenbush	F. A. Moesel
KUCERA, HENRY T., Vice-Pres., Marsh Tritrol Co., Chicago, Ill.	J. F. Collins, Jr.	E. C. Webb
	C. H. Bevington	E. N. McDonnell
LITTLE, RAYMOND, Com. Mgr. & Utilization Engr., Equitable Gas Co., Pittsburgh, Pa.	J. F. Collins, Jr.	T. F. Campbell
	L. S. Maehling	E. C. Smyers
LORIMER, CARL F., Br. Mgr., Kewanee Boiler Corp., Columbus, Ohio.	H. R. Allonier	John Slemmons
	*F. N. Schaad	C. E. Bronson
LUTTRELL, LEE W., Chief Engrg. Draftsman, U. S. Coast Guard Headquarters, Civil Engrg. Div., Washington, D. C.	T. H. Urdahl	F. A. Leser
	J. W. Markert	A. S. Gates, Jr.
MACKEY, C. OSBORN, Prof. Heat-Power Engrg., Cornell University, Ithaca, N. Y.	W. M. Sawdon	*F. O. Ellenwood
	D. Dropkin	*W. N. Barnard
MAUTNER, ERWIN W., Partner, Mid West Heat Service, Chicago, Ill.	S. L. Haas	E. M. Mittendorff
	A. O. May	S. R. Lewis
MCCONACHIE, L. L., Owner, L. L. McConachie Co., Detroit, Mich. *(Advancement)*	A. E. Knibb	W. H. Old
	E. D. Sheley	M. B. Shea
MCDERMOTT, PAUL F., Section Chief, Research Lab., Johns-Manville Corp., Manville, N. J.	F. C. Houghten	E. O. Eastwood
	F. B. Rowley	A. V. Hutchinson
NOTTAGE, HERBERT B., Asst. Project Engr., Pratt & Whitney Aircraft, East Hartford, Conn.	C. M. Ashley	*E. A. Ryder
	W. H. Carrier	*J. H. Marchant
PASTEUR, HUGH W., Export Mgr., J. E. Hall, Ltd., Kent, England.	C. B. Morrison	Walter Yates
	H. W. J. Lipscombe	W. W. Nobbs
PEGG, EDWARD H. R., Mech. Engr., Westinghouse Elec. & Mfg. Co., Cleveland, Ohio.	J. L. Foley	E. W. Gray
	G. W. Penney	D. L. Taze
PIZER, M. MORTON, Engr., Daniel-Morris Co., Inc., New York, N. Y.	A. R. Herske	Martin Jarcho
	A. V. Hutchinson	C. H. Flink
PORTER, CARL W., Assoc. Engr., Navy Dept., Bureau of Ships, Washington, D. C. *(Reinstatement)*	T. H. Urdahl	J. H. VanAlsburg
	E. R. Queer	G. P. Lively
RICHMOND, K. C., Editor, Coal-Heat, Chicago, Ill.	E. N. McDonnell	George LaRoi
	A. V. Hutchinson	R. E. Moore
SCOTT, WIRT S., Air Cond. Engr., Philadelphia Electric Co., Philadelphia, Pa.	H. H. Mather	G. E. Tuckerman
	Joseph Call	H. G. McCullough
SIMMONDS, VERNE, Mech. Engr., U. S. Engrg. Office, Omaha, Nebr.	B. G. Peterson	W. R. White
	W. A. Goll	E. F. Adams

SMITH, LAWRENCE J., Dir. of Research, Bell & Gossett Co., Morton Grove, Ill.

WHITE, JOHN HAZEN, Pres. & Treas., Taco Heaters, Inc., New York, N. Y.

WILLIAM, FREDERIC C., Sales Engr., American Blower Corp., Boston, Mass.

WRIGHT, L. T., JR., Asst. Prof. Heat-Power Engrg., Cornell University, Ithaca, N. Y.

S. R. Lewis
C. W. DeLand
M. F. Blankin
R. L. Blanding
F. A. Leser
W. F. Raymer, Jr.
W. M. Sawdon
David Dropkin

C. E. Pullum
R. E. Moore
J. R. Murphy
H. A. Essley
C. W. Kimball
*R. S. Reed
*F. O. Ellenwood
*W. N. Barnard

*Non-member.

Candidates Elected

In the past issues of the Journal of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

ABBOTT, FURMAN S., Engr., Frank A. McBride Co., Paterson, N. J.

BADE, RUDOLPH E., Dist. Mgr., B. F. Sturtevant Co., Kansas City, Mo.

BLOOMSTER, EDGAR L., Consulting Engr., San Francisco, Calif.

EPPLE, ARNET B., Instructor, Michigan College of Mining & Technology, Houghton, Mich. *(Reinstatement and Advancement)*

GARRISON, C. HILL, Mfrs. Repr., C. H. Garrison Co., Kansas City, Mo.

GATES, ALBERT S., JR., Assoc. Engr., Bureau of Ships, Navy Dept., Washington, D. C. *(Advancement)*

HALL, JOHN AYER, Sales Engr., A. L. Vanderhoof, Inc., Cleveland, Ohio.

HAMBLIN, CLYDE M., Principal Engr., Bureau of Ships, Navy Dept., Washington, D. C.

HANSEN, W. A., Mech. Engr., A. A. Coddington, San Francisco, Calif.

HEINDEL, RICHARD A., Assoc. Engr., U. S. Navy Dept., Washington, D. C.

HILL, VAUGHN H., Mech. Engr., Board of Water & Electric Light Comm., Lansing, Mich. *(Advancement)*

HOLMAN, EARL LEIGH, Sr. Engr., Chief of Bldg. & Utilities Subdiv., Engrg. Div., District Engrs. Office, U. S. Army, Honolulu, T. H.

HOW, CECIL PERCY, Dir. & Gen. Mgr., Brightside Foundry & Engrg. Co., Ltd., Birmingham, England.

HOW, RALPH FREDRICK, Htg. Engr., U. S. Engineering Co., Kansas City, Mo.

IZATT, GEORGE S., Supt. of Bldgs., Board of Education, Hamilton, Ont., Canada.

KEELING, FRED V., Assoc. Mech. Engr., U. S. Navy Yard, Public Works Dept., Philadelphia, Pa. *(Advancement)*

KING, T. EDWARD, Vice-Pres., Lord & Burnham Co., Irvington, N. Y.

MACDERMOT, S. G., Mgr., Construction Dept., Canadian Johns-Manville Co., Ltd., Montreal, P. Q., Canada.

MARSHALL, JAMES, Asst. Chief Engr., The Bahnson Co., Winston-Salem, N. C. *(Advancement)*

MCCUNE, L. J., Bldg. Supt. & Engr., Springer Interests, Tulsa, Okla.

OWEN, W. HAROLD, Mech. Engr., Harry Cooper Supply Co., Springfield, Mo.

PARKER, HERBERT E., Engr. in Charge Htg., Vtg., Air Cond., Bethlehem Steel Co., Quincy, Mass.

PATTERSON, JAMES L., Works Engr., Canada Cycle & Motor Co., Ltd., Weston, Ont., Canada.

PECK, ROBERT E., Vice-Pres., Peck, Hannaford & Briggs Co., Cincinnati, Ohio.

RAINEY, WALTON, Combustion Engr., Anthracite Industries Lab., Primos, Pa.

RICHARDSON, FRANK C., JR., Sales Engr., A. L. Vanderhoof, Inc., Cleveland, Ohio.

RUSSELL, W. A., Chief Engr., Skinner Htg. & Vtg. Co., Inc., St. Louis, Mo. *(Advancement)*

SCOTT, JAMES, Br. Mgr., York Ice Machinery Corp., Cincinnati, Ohio.

SINGMASTER, J. WALTER, Pres., Lehigh Valley Supply Co., Allentown, Pa.

SMITH, ERNEST T., Engr., The Detroit Edison Co., Detroit, Mich.

STERNE, CECIL M., Lt.-Comdr., Bureau of Ships, Navy Dept., Washington, D. C. *(Advancement)*

STOUT, A. G., Chief Mech. Engr., for associated contractors, Park Ridge, Ill.

SULLIVAN, WILLIAM HENRY, Pres., W. H. Sullivan Co., Inc., Greensboro, N. C.

WALTERS, JOSEPH K., Engr., Robert Schoenijahn, Cons. Engr., Wilmington, Del.

WILLIAMS, WILLIAM A., Engr., General Electric Co., West Lynn, Mass.

WILSON, DONALD PHIPPS, Chief Draftsman, McQuay, Inc., Minneapolis, Minn.

ASSOCIATES

BENNIS, RAYMOND R., Chief Engr., Contractors Refrigeration Corp., Elmhurst, N. Y.

BENTSON, ROBERT J., Engr., General Electric Co., West Lynn, Mass.

CALLAN, JOHN J., JR., Mgr., Htg. Equip. Dept., Claflin-Sumner Co., Worcester, Mass.

COAD, J. DENNIS, Owner, D. C. Air Conditioning Service Co., St. Louis, Mo.

FITZMORRIS, THOMAS B., Power Supt., General Mills, Kansas City, Mo.

HARVEY, ERNEST W., Application Engr., Westinghouse Elec. & Mfg. Co., Kansas City, Mo.

KLEINHOMER, WILLIAM G., Mech. Designer, Wilputte Coke Oven Corp., New York, N. Y.

PALMER, CECIL NORRIS, Mgr., Stoker Div., Pease Foundry Co., Ltd., Toronto, Ont., Canada.

PENTECOST, RICHARD H., Sales Mgr., Airtherm Mfg. Co., St. Louis, Mo.

PIERPOINT, HARRY Y., Owner, J. A. Pierpoint, Washington, D. C.

TASNEY, JOHN S., Mgr. Sales & Service, Parker Bldg. Specialties, Inc., San Francisco, Calif.

JUNIORS

EPSTEIN, LEON S., Asst. Engr., Bureau of Ships, Washington, D. C.

HONEY, ROBERT L., Sales Engr., McQuay, Inc., Minneapolis, Minn.

LANGDON, TOM COLEMAN, Sales Engr., T. C. Langdon Co., Portland, Ore.

TEMPLE, HAROLD L., P/O, Royal Air Force, Honeybourne, Worcester, England.

TILLOTSON, J. J., Mgr. Air Cond. Engrg. & Service, Danforth Co., Pittsburgh, Pa.

STUDENTS

DAHL, LAWRENCE JOSEPH, Student, University of Minnesota, Minneapolis, Minn.

LANGAN, JAMES, Student, Carnegie Institute of Technology, Pittsburgh, Pa.